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THE EDISON PORTLAND CEMENT WORKS AT NEW VILLAGE, N. J.

The origin of the Edison cement works can be traced directly to the famous inventor's works at Ogden, N. J., for the utilization of lean iron ores by crushing and magnetic concentration. The record of that enterprise is for the present a matter of past history, and all that need be noted here is that in carrying it out Mr. Edison worked out a very elaborate system of roll crushers for reducing the ore to sufficient fineness to be handled by the magnetic separators. The success of these crushers in handling the iron ore at Ogden indicated that they would serve admirably for the reduction of cement rock and cement clinker in the manufacture of Portland cement. So thoroughly was Mr. Edison convinced of the possibilities of his rolls in this class of service that he undertook the rather venturesome task of constructing a cement mill equipped with them in lieu of the standard grinding and crushing machinery, whose efficiency has been demonstrated by a multitude of experienced competitors.

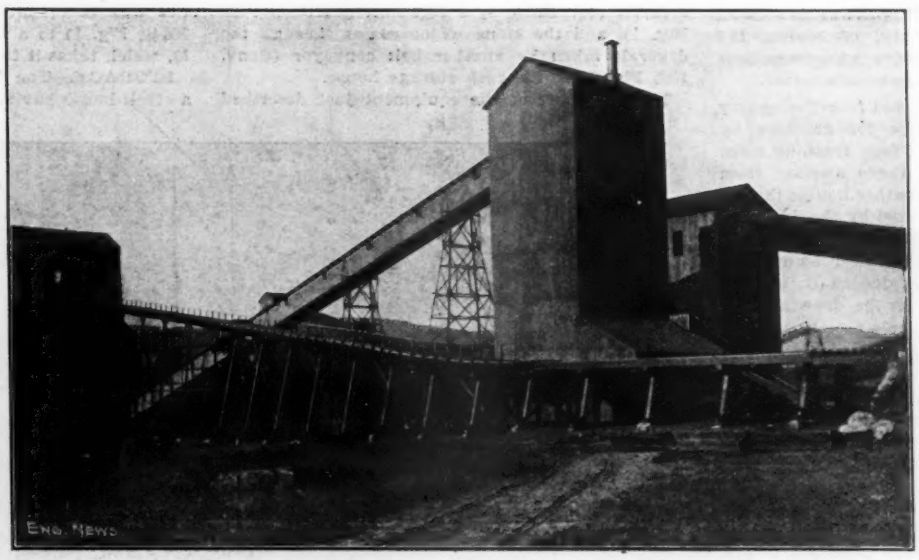
It may be said, therefore, that the works at New Village have been constructed around a set of Edison crushing and grinding rolls. As the plans were developed other novelties in equipment and construction were evolved by the builder, but the distinctive feature of the works is the use of roll crushers and grinders for both the raw material and the clinker.

The location that most naturally suggested itself for the new works was the cement rock district of eastern Pennsylvania and western New Jersey. Here the raw materials were cement rock and limestone requiring crushing and grinding to fit them for calcination. Furthermore, this district is the greatest center of cement production in the United States, and is convenient of access to Mr. Edison's laboratories at Orange, so that his personal supervision of the construction work was easily possible.

While the probabilities were all in favor of this district as the best location, confirmation was given to the probabilities by the work of a geological survey party which was kept in the field for several months, with instructions to determine the best location for a Portland cement making plant in the East, having regard, of course, to the accessibility to markets as well as the character of the raw material.

The report of this survey party settled the location of the plant in the Lehigh region, and search among the available cement properties of that district disclosed a deposit of cement rock and limestone in close juxtaposition at New Village, N. J., a location well within the New Jersey section of the cement rock district. This deposit and the adjoining property were purchased and the construction of the works was begun about three years ago.

The site selected for the works was a practically level tract about 1½ miles from the cement rock quarry. Here a plant capable of producing 10,000 barrels of cement per day was laid out in such a manner that it could be built to a fraction of its capacity at first and then enlarged by successive additions until its full projected capacity was attained. In the accompanying diagram plan, Fig. 1, the portions shown by broken lines are those designed for future construction. The arrangement and co-ordination of the several parts of the works are best discussed after an idea of the sequence of processes and machines has been given.



A TYPICAL VIEW OF BELT CONVEYOR HOUSINGS AT THE EDISON PORTLAND CEMENT WORKS.

(Trestle incline to rock crushing house in foreground.)

QUARRYING AND REDUCTION OF THE RAW MATERIALS.

QUARRYING.—The raw material employed by the Edison cement works is the argillaceous limestone of the Lehigh district, commonly known as cement rock, to which is added the necessary portion of comparatively pure limestone to give the proper proportion of calcium carbonate in the raw mixture. Both the limestone and the cement rock are obtained from the same quarry, but, of course, from different portions. This quarry is located about a mile from the mills, and the rock comes quite close to the surface, so that the stripping is a small factor of the cost of getting the rock. The quarrying methods do not differ greatly from ordinary cement works practice. The pits are opened up rather narrow and are extended trench-like by working a rather high end face. For breaking down the rock percussion drills and dynamite are used in connection with 90-ton steam shovels. These shovels load the detached and loosened rock into steel-plate skips of 5 tons capacity, which are set loose on small flat cars. Aside from the steam shovels, the equipment of the quarry is of the usual character for getting out fragmentary rock. It is planned, however, to adopt the unusual feature of covering the quarry by a roof over the working face and shovels. The plan is made possible by the narrow and deep cut by which the quarry is being developed. This cut is about 60 ft. wide between the sides at the ground surface, and it is proposed to build a cribwork track along each edge and mount on this a steel frame roof spanning the cut. As stated above, this roof will cover only the end of the cut where rock is being taken out, and will be so mounted that it can be moved ahead as the work progresses.

The rock is taken from the quarry to the works on trains of flat cars, each car carrying a loaded skip; these trains are hauled by small locomotives to a car shed located on the railway just beyond the limits of the drawing, Fig. 1. Here the train is divided into sections of three cars each, which are run by gravity to the foot of the incline leading to the rock-crushing house. This incline is a timber trestle constructed as shown by the view, Fig. 2, and the cars are hauled up it by wire cable operated by an electric hoist. The incline tracks lead onto the floor of the crusher house, where the skips are dumped, one at a time, by means of a special dumping device, as shown by Fig 3. The construction and operation of this dumping device are indicated in more detail by Fig. 4. This drawing is so complete that very little explanation is needed. The operator controls the hauling of the cars up the incline and also the operation of the dumping device from the same platform. He

can, therefore, "spot" cars exactly, so that the bail on the skip is in the proper position to engage with the hook on the dumping device. The dumping of the skips is, therefore, an entirely automatic operation.

After the stone cars are unloaded they are run back down the incline and by gravity onto a switch track, which passes them by the car shed to the main track beyond, where they are made up into trains to be taken back to the quarry. The whole operation of handling the stone cars at the mills is automatic, except, of course, the breaking up of the trains and the subsequent process of assembling the cars again into trains.

CRUSHING.—The rock received from the quarry is reduced to the proper size for grinding by passing it through a series of four crushing rolls. These rolls are located one above another from the top to the bottom of the crusher house; the arrangement is fairly well indicated by the drawings of Fig. 5, which show the driving arrangement in diagram. As will be seen, all the rolls are belt driven from pulleys on the engine shaft, and all the essential sizes are given on the drawings.

The first or topmost set of rolls receives the rock just as it comes from the quarry, and is capable of taking in rocks of 5 tons capacity. These rolls are 5 ft. in diameter and 5 ft. long, and weigh approximately 25 tons each. The view, Fig. 6, shows the roll housing quite clearly. It will be noted that a segment of the casing has been raised to give a view of the roll. The housing is about 18 ft. long and 10 ft. wide. The wearing or crushing surfaces of the rolls are composed of corrugated segments of chilled iron and are attached to the body of the rolls by countersunk stud bolts. A very fair idea of this construction is had from Fig. 6, and also from Fig 7, which is a view looking vertically downward into the hopper above the rolls. The rolls are set rigidly and the space between them is 8 ins. The method of driving them is shown by Fig. 5.

As stated above, the 5-ft. rolls take all rock up to 5-ton sizes. After passing between the rolls the rock drops into a 10-ton hopper, from which it is fed to the first 36-in. rolls and then to the second and third 36-in. rolls by gravity. The method of driving the 36-in. rolls is shown clearly by Fig. 5. They each have two rolls 36 ins. in diameter and 36 ins. long, with a crushing face 28 ins. long. The first or uppermost set have a flywheel to enable them to handle the large pieces that come from the 5-ft. rolls, but the other sets are not so equipped. The rolls of the first and second set are set rigidly at fixed distances between faces, but the rolls of the third set are held together by coiled springs. These last rolls also handle the coarse material which is returned from the screens of the dryers.

DRYING.—From the last crushing roll the stone broken to below ½-in. size is fed into a belt conveyor (Conv. 101, Fig. 1), and conveyed to the top of the dryer house, where it passes by gravity through screens and the hot-air dryer; the spalls from the screens are taken back to the third 36-in. rolls for recrushing by a belt conveyor (Conv. 99, Fig. 1), and the stone which comes through the dryer is taken by another belt conveyor (Conv. 102, Fig. 1) to the rock storage house.

The only part of the equipment just described which calls for special notice is the dryer. In rock drying for cement manufacture the almost universal practice is to employ rotary dryers. A departure has been made in the Edison works by installing the form of dryer shown by Figs. 8 and 9. This dryer consists of a rectangular box, 8 x 8 ft. laterally, and 40 ft. high, which is filled with baffle plates. The top set of these plates is vibrated by a shaker mechanism to prevent clogging, but the remaining plates are stationary. The arrangement is clearly shown by Fig. 8. As the material falls through the dryer it is dried by the ascending current of hot air from the furnace at the bottom. The construction of this furnace and its connection with the dryer are shown by Fig. 9. The ascending gases are exhausted from the top of the dryer by an 80-in. fan and delivered into a dust separator, where the rock dust settles and is taken by a screw conveyor (Conv. 101½, Fig. 1) to a belt conveyor (Conv. 102, Fig. 1), which takes it to the stock house.

STORAGE.—The dried rock is stored for use in a stock house having a storage capacity of 10,500 tons. The mixing of the rock is also done in this stock house and its adjacent transfer towers. Delivery to and from the stock house is accomplished as follows: The conveyor from the dryer (Conv. 102, Fig 1) ascends to the top of transfer tower No. 1, where it delivers onto a belt conveyor (Conv. 103, Fig. 1), which runs lengthwise of the stock house over the bins. As the material is

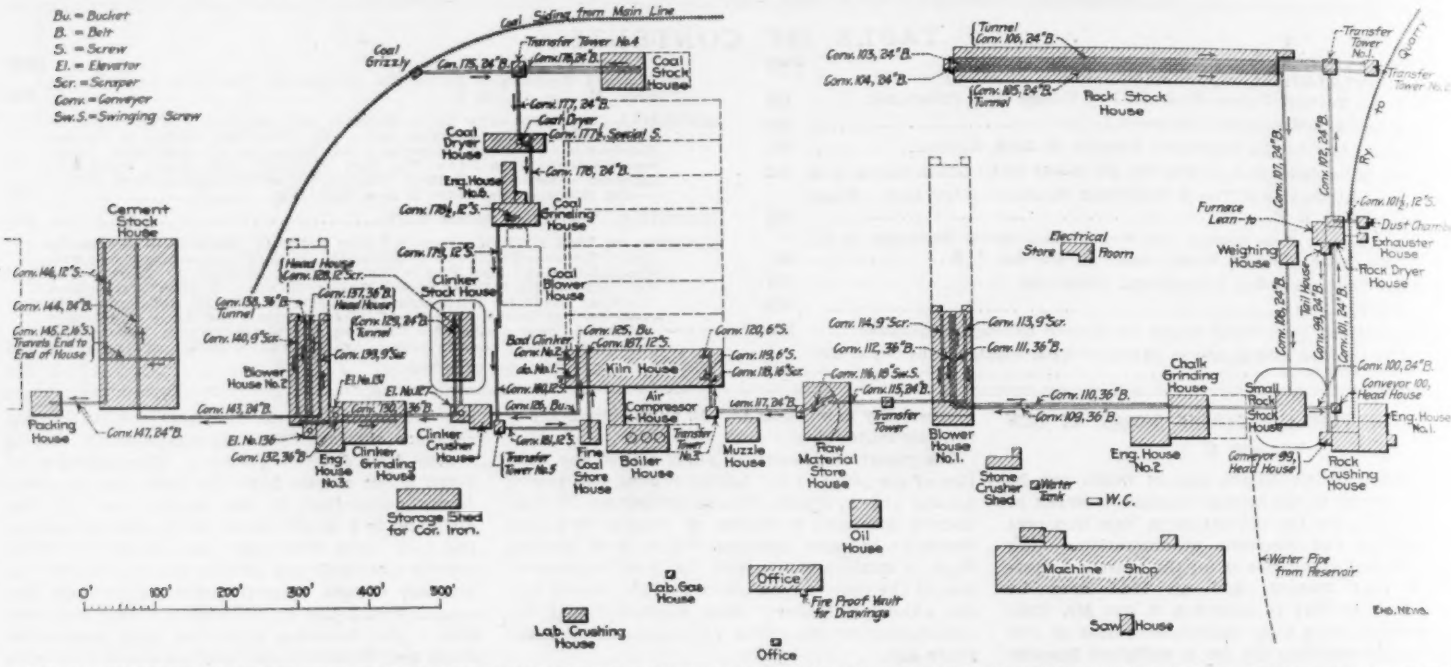


FIG. 1. DIAGRAM PLAN OF THE EDISON PORTLAND CEMENT WORKS, SHOWING THE CONVEYOR SYSTEM WITHIN AND BETWEEN BUILDINGS.

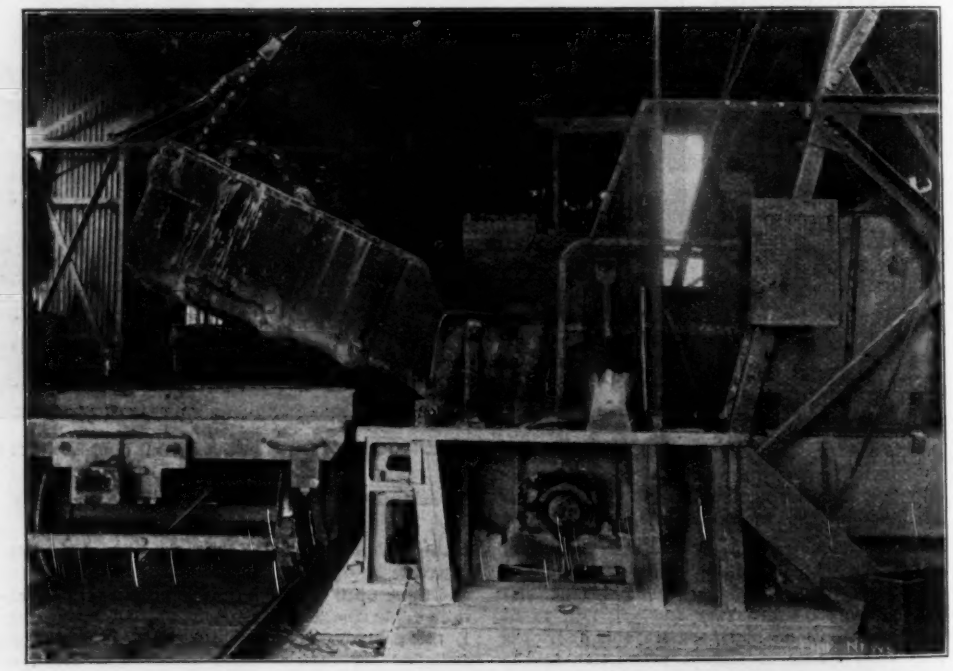


FIG. 3. VIEW SHOWING AUTOMATIC DUMPING OF SKIPLOAD OF STONE INTO CRUSHERS.

transferred in the tower an automatic device takes samples every 2½ minutes. The conveyor through the stock house (Conv. 103, Fig. 1) delivers into any one of the bins chosen by means of a movable tripper. There are seven bins, each holding 1,500 tons of rock, and four of these bins are used for cement rock, two for limestone and one is used for mixing.

The mixing operations in the stock house are performed by means of two conveyors (Convs. 104 and 106, Fig. 1) and transfer tower No. 2. Conveyor 106 is located in a tunnel underneath the bins and extends to the top of transfer tower No. 2. It is able to take material from any number of the bins. In the transfer tower the rock delivers onto a belt conveyor (Conv. 104, Fig. 1) which runs over the bins, and is enabled by a movable tripper to discharge into any of the bins. The mixing done in the stock house is for the purpose of eliminating quarry irregularities in the cement rock and the limestone. Limestone from one bin is mixed with limestone from another bin until the contents of all the limestone bins are uniform in quality. In the same way cement rock is mixed with cement rock. Limestone and cement rock are not combined in the stock house.

The delivery of rock from the stock house to the mill is accomplished by a second belt conveyor (Conv. 105, Fig. 1), which is located in the tunnel running underneath the bins. The drawings of Fig. 10 show the tunnel, the discharge chutes from the bins and the mechanism for controlling the delivery onto the belts. As will be seen from Fig. 1, the stock house is provided with an exhaust fan and furnace, so that if desired a current of warm air may be drawn through the house to keep it dry.

MIXING.—The mixing of the limestone and the cement rock is performed in a separate building known as the weighing house. Material from the tunnel conveyor (Conv. 105, Fig. 1) is delivered to the top of the weighing house by a belt conveyor (Conv. 107, Fig. 1) and there delivered into bins. There are two of these bins, one for cement rock and the other for limestone, and each has a capacity of 50 tons. From these bins the material is fed separately into weighing hoppers, where the proper proportion of each is weighed out. The hoppers are discharged together through mixing plates to a belt conveyor (Conv. 108, Fig. 1), which delivers to the small rock stock-house. This small stock-house has a capacity of 1,000 tons of material ready for grinding.

GRINDING.—The rock from the small stock house is taken to the grinding house by a belt conveyor (Conv. 109, Fig. 1) in tunnel, which extends to the blower house. The grinding is done by a three-roll grinder, a plan and elevation of which are shown by Fig. 11. These rolls are all 28 ins. in diameter, and have 8-in. faces. One roll is driven from the main shaft and the others are driven by friction from the direct driven roll. The chief feature of interest in the construction of the grinding rolls is the tension device for keeping the roll faces in pressure contact. The pressure with which the rolls are held together is about 18,000 lbs. per square inch, and it is obtained by having a number of loose sheaves on the ends of the two outside rolls on each side of the machine. An endless rope is reaved over these sheaves similarly to a block and fall rig. There is a sheave in the bight of this rope, which is connected to a cylinder, to which compressed air may be admitted

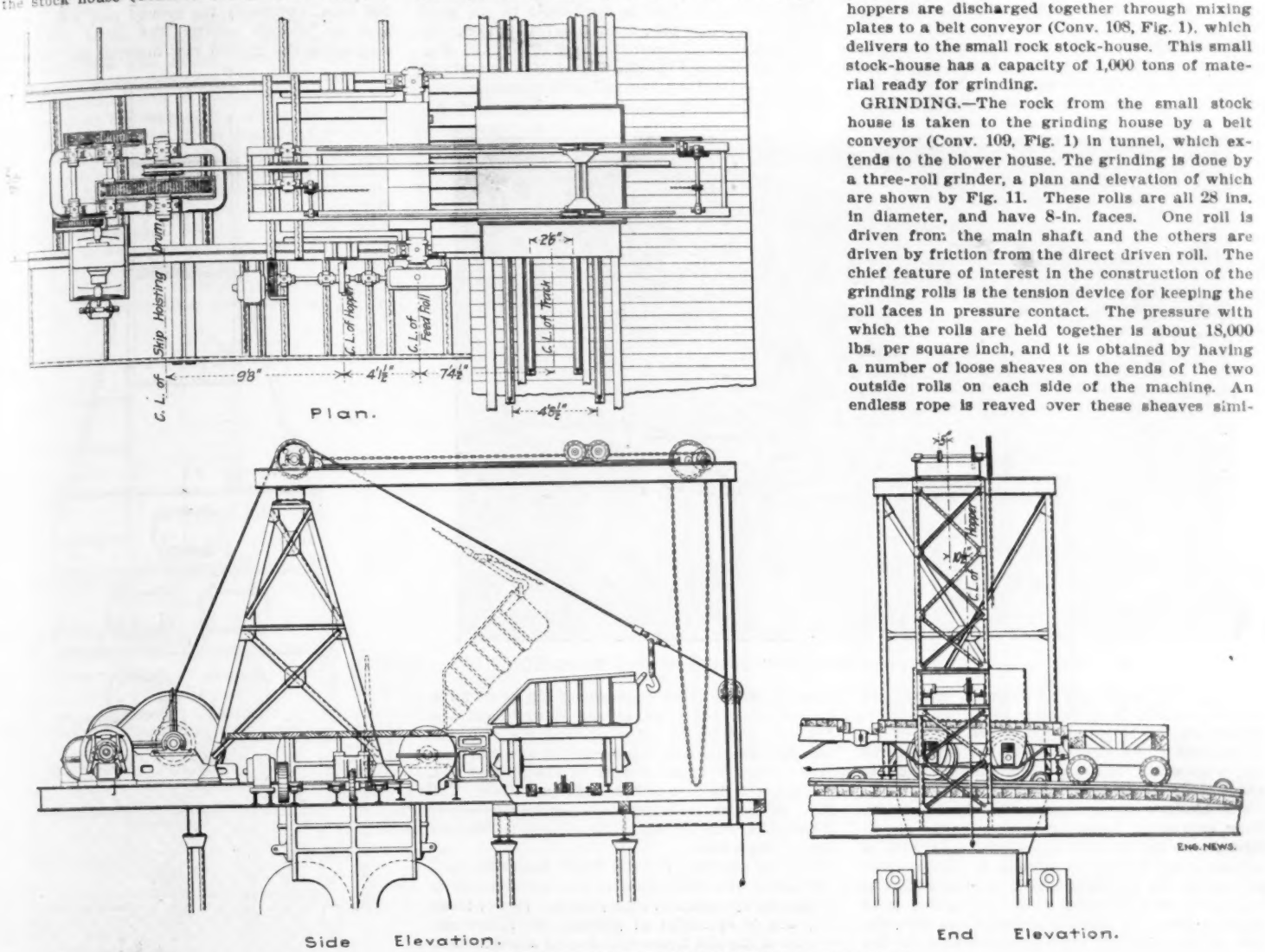


FIG. 4. DETAILS OF DEVICE FOR DUMPING STONE SKIPS.

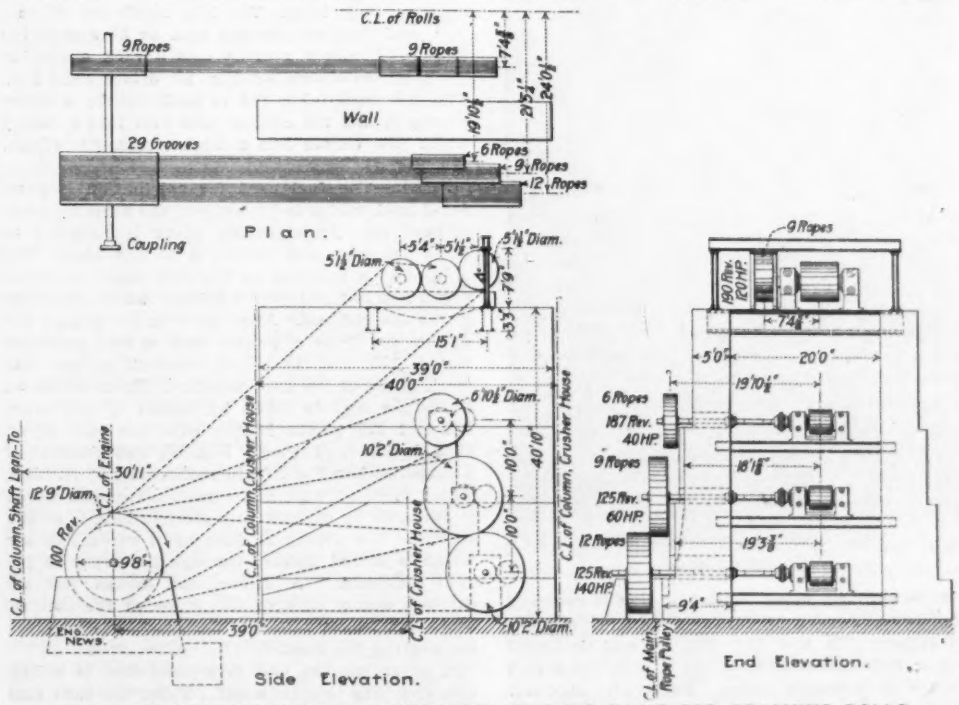


FIG. 5. DIAGRAM SHOWING ARRANGEMENT OF ROPE DRIVE FOR CRUSHING ROLLS.

under any desired pressure. By this arrangement the heavy pressure between the rolls is obtained without any pressure on the bearings except that due to the weight of the rolls themselves.

SEPARATING.—The separation of the fine from the coarse material from the grinding rolls is accomplished by air current in the blower house. From the grinding rolls the belt conveyor (Conv. 109, Fig. 1) previously mentioned takes the ground material to the blower house and delivers it onto another belt conveyor (Conv. 111, Fig. 1), which runs lengthwise of the blower house at the top, and which has two 5-in. dumps, each of which feeds eight blowers.

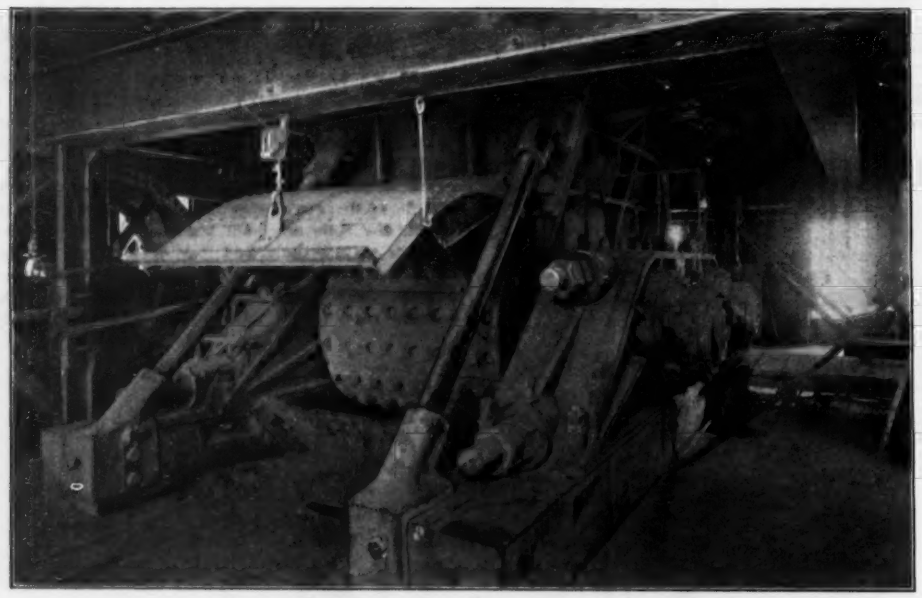


FIG. 6. VIEW OF 5-FT. CRUSHING ROLLS WITH CASING PARTLY REMOVED.

The blowers are comparatively simple affairs. They consist of boxes containing baffle plates, through which the ground material falls while a current of air is passing through it. The moving air carries the fine dust into a settling chamber, where the reduced speed of the air allows it to settle to the floor. The air is then taken from the tops of the chambers and delivered back to the blowers through pipes. The fine dust is removed from the chambers by means of scraper conveyors (Convs. 113 and 114, Fig. 1) and delivered onto a belt conveyor (Conv. 115, Fig. 1), which takes it to the stock house. The coarse material which is rejected by the blowers is carried by chutes to belt conveyor 112, which transfers it to belt conveyor 110, which returns it to the feed rolls over the grinding rolls for regrinding.

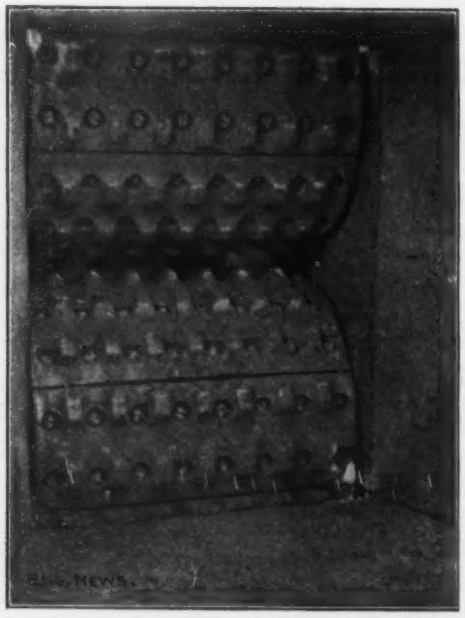


Fig. 7. View Looking Downward Between 5-Ft. Crushing Rolls.

The separated dust is discharged in the store house in a single pile, from which it is taken by the novel form of screw conveyor (Conv. 116, Fig. 1) illustrated in Fig. 12. This device consists of a truss pivoted at one end and traveling on a track at the other end. From the bottom of the truss is hung a screw conveyor of the usual form. In operation the truss swings slowly back and forth on the track and pivot and the conveyor eats into the edge of the deposit of raw material and conveys it to the hopper at the pivoted end, whence it falls onto a belt conveyor (Conv. 117, Fig. 1), which transfers to a scraper conveyor (Conv. 118, Fig. 1), which distributes it into the bins of the kilns.

CALCINATION OF THE RAW MATERIAL.

KILNS.—The calcination of the raw material is performed by means of rotary kilns. Two of these only are in operation at present, but future extension of the kiln house sufficient to accommodate 16 more has been provided for. The kilns are of the ordinary rotary type, but have been constructed with the extraordinary length of 150 ft. Fig. 13 is a dimensioned drawing of one of the kilns, and Fig. 14 is a view down the kiln house showing both kilns. The kiln shells are of cast iron, and they are carried each on 30 supporting wheels. A motor gearing into a rack encircling the shell, as shown by Fig. 13, drives each kiln. The raw material is fed to each kiln by a screw conveyor, and the clinker falls first into a rotary cooler and thence into a bucket conveyor (Conv. 125, Fig. 1).

FUEL.—The fuel used for calcination is powdered coal, which is blown into the kilns by compressed air. An elaborate plant is required to grind the coal and deliver it to the kilns. The lump coal is received on the side track shown in Fig. 1 and dumped over a grizzly, where the large pieces are reduced. After passing the grizzly the coal is fed from a hopper onto a belt conveyor (Conv. 175, Fig. 1), which takes it to the coal stock house of 800 tons capacity. From the stock house the coal is taken by means of conveyors 176 and 177 to the hopper over the coal dryer. This device is shown by Fig. 15, and consists of a cast-iron box 6 × 7 ft. in section and 18 ft. high, which is fitted with baffle plates, between which it descends by gravity to a storage hopper at the bottom. The drying is done by a current of air which is passed upward through the dryer as the coal descends. A 110-in. fan forces the air through steam coils to the dryer at the rate of 30,000 cu. ft. per minute. Exhaust steam is used for heating the coils.

After drying the coal is ground first in a ball mill and then in a tube mill. From the tube mill the fine coal is taken by twin-screw conveyors 179, 180 and 181 to the storage house, whence it is delivered to the kiln bins by screw conveyor 187. The fine coal storage bins have a capacity of 100 tons. Originally the ground coal was separated by blowers exactly like those used for separating the ground raw material and cement.

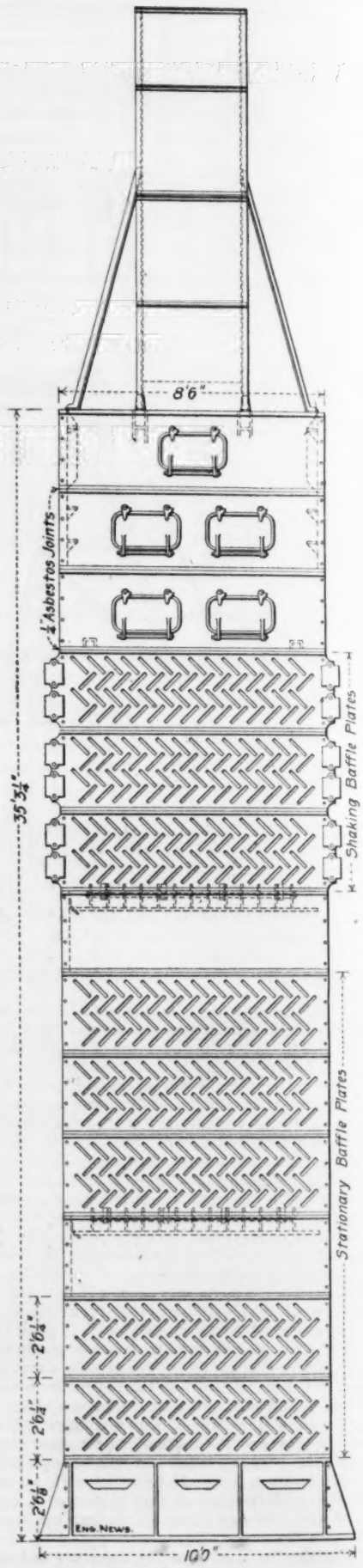


Fig. 8. Elevation of Stack Dryer for Broken Stone.

A disastrous explosion of dust in the blower house occurred shortly after the plant was started, and the method of air separation has since that time been abandoned.

REDUCTION OF THE CLINKER.

CRUSHING.—The clinker from the rotary coolers is delivered onto bucket conveyor 125 and thence onto bucket conveyor 126, which takes it to the first set of rolls in the crusher house. In its journey to the crusher house the hot clinker receives a water spray at two points and in addition both conveyors are open to the air for the greater part of their length. These are the only provisions for clinker cooling before crushing. The crushing is done by two sets of 36-in. roll crushers set one above the other, and the exact duplicates in all particulars of the 36-in. rock crushing rolls. From the second set of rolls the clinker is elevated to a scraper conveyor (Conv. 128, Fig. 1), which runs along the top of the clinker stock house of 2,500 tons capacity and deposits its load in a large pile.

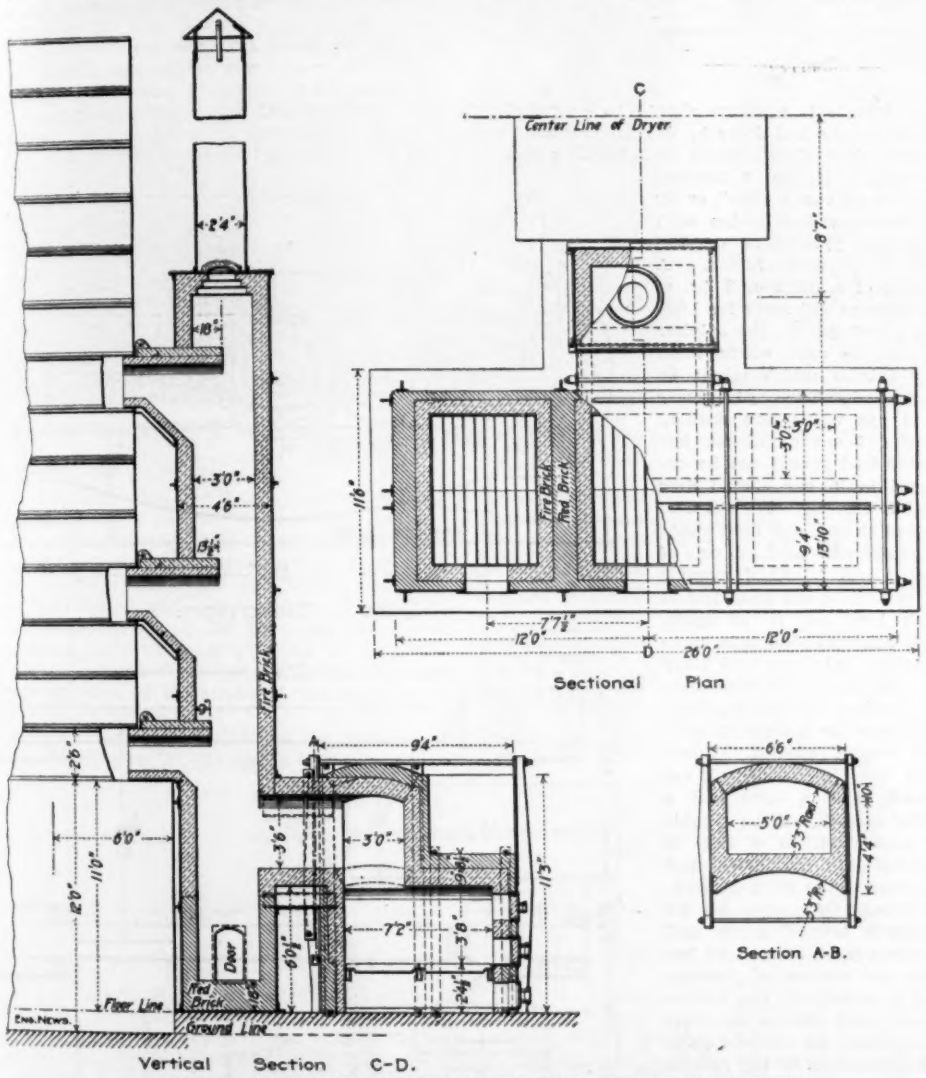


FIG. 9. PLAN AND SECTION OF FURNACE FOR STACK DRYER.

GRINDING AND SEPARATING.—From the pile in the stock house the clinker is delivered by chutes onto a belt conveyor (Conv. 129, Fig. 1) in tunnel, where the proper amount of sulphate of lime is added. The clinker is then taken by belt conveyor 130 to elevator 131; belt conveyor 130 also receives the discharge of the two sets of clinker-grinding rolls in the cement-grinding house. From elevator 131 the material chutes to conveyor 137 and is distributed to 16 blower separators. The grinding rolls and the separators are duplicates of those used for grinding and separating the raw material. The coarse material from the separators is taken by belt conveyor 133 to belt conveyor 132, which by means of S dumps, delivers it to the feed roll hopper over the grinding rolls.

The fine cement from the separators is removed from the dust bins by scraper conveyors 139 and 140, and from them it is taken by conveyors 143 and 144 to the cement stock house of 100,000 barrels capacity. In the stock house the cement is dumped in two piles, one at each end. Between the two piles is a traveling screw conveyor. Like the swinging screw conveyor in the raw material store house, this device consists of a screw conveyor suspended below and in line with a vertical steel truss. This truss extends transversely across the building and is carried on wheels at each end, which permit it to be moved back and forth lengthwise of the building and thus to feed into the piles of cement and take it to the channel hopper over screw conveyor 146. Conveyors 146 and 147 carry the cement to the packing house, which is equipped with four bagging machines and two barreling machines.

POWER PLANT.

Power for the operation of the plant is generated by several separate generators. For operating rock crushing rolls by belt drives a vertical compound condensing engine of 500 HP. is installed in engine house No. 1, Fig. 1. The rock-grinding plant is driven by a 700-HP. vertical compound condensing engine located in engine house No. 2. In this same house there are two other engines connected to generators which supply the current for the motor operation of the conveyors, fans and elevators throughout the plant. These motors, it is worth noting, are all inclosed in houses made of gunny cloth, nailed over a wooden frame, to protect them from the flying dust. A view of one of these motor houses is shown by Fig. 16. The coal-grinding machinery is driven by a 250-HP. horizontal tandem compound engine, located in engine house No. 6. The clinker-grinding rolls are driven by a 700 HP. engine in engine house No. 3. The compressed air power plant is located at one side of the kiln house and has a capacity of 1,600 ft. of free air per minute.

CONVEYORS.

In no modern industry, perhaps, has the automatic handling of material by conveyors been developed to a higher degree of usefulness than in the up-to-date American Portland cement plant. The conveyor system of the Edison cement works is especially elaborate, as will have already been inferred from the preceding description. Owing to the magnitude of the plant and the consequent wide separation of the buildings the use of belt conveyors for overcoming vertical distances is unusually extensive. These conveyors require only brief mention. The belts are in all cases carried on horizontal rollers instead of on troughed rollers, and they are made with small triangular flanges at the edges to increase their capacity and restrain spilling over the edges. The screw conveyors and the bucket elevators are of the usual types and call for no further mention. In the scraper conveyors, however, one novelty has been introduced in substituting sliding shoes in place of the usual wheels on the carrying chains. A detail of this construction is shown by Fig. 17.

THE FINISHED PRODUCT.

The character of the finished product of the Edison cement mills is indicated by the following results of an analysis and tests made at the laboratories of Lathbury & Spackman, Philadelphia, Pa.:

Fineness:
Passing No. 100 Sieve, 99.8%
" " 200 " 91.6%

Constancy of Volume Test:
Normal Pat. Test Am. Soc. Civ. Engrs.
Cold Water Pat.....Good
Air Pat.....Good

Setting Time:
Initial Set.....2 hrs.
Final Set.....6 hrs. 30 min.
Per cent. of Water.....25
Temperature of Air.....72°F.
Temperature of Water, 73°F.

Accelerated Test:
Boiling Water Test.....Good
Specific Gravity.....3.16

Tensile Strength of Standard Briquettes (1 square in. section).

Composition	% of Water	Time In Air	Time in Water	Total Time	Strength in Lbs. Briquettes
Neat	24	24 hrs.		24 hrs.	313 366 378 300 328 Ave. 325
Neat	24	24 hrs.	6 dys.	7 dys.	710 690 665 655 660 Ave. 676
1 Cement 3 Sand	10	24 hrs.	7 dys.	7 dys.	250 283 242 244 255 Ave. 255
1 Cement 3 Sand	10	24 hrs.	27 dys.	28 dys.	328 319 326 338 346 Ave. 331

Chemical Analysis:

Silica	SiO_2	20.14%
Alumina	Al_2O_3	7.51%
Iron Oxide	Fe_2O_3	3.33%
Lime	CaO	62.71%
Magnesia	MgO	2.34%
Sulphuric Anhydride	SO_3	1.64%

Ratio Lime to Silica 3.11 to 1.

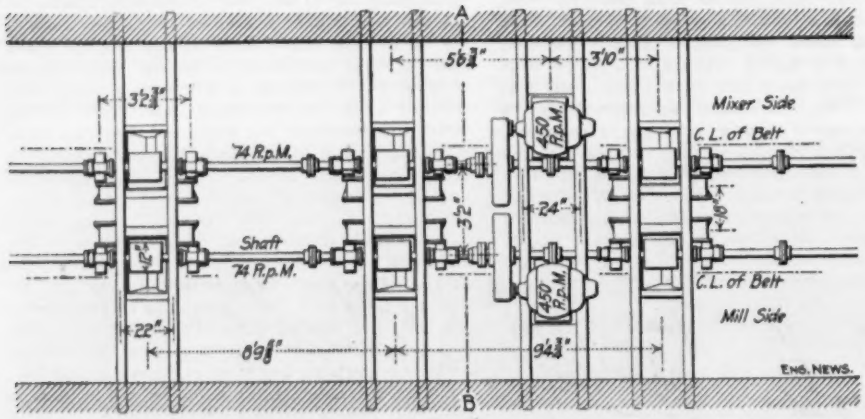
THE MOSQUITO EXTERMINATION CONFERENCE.

What is described as "The First General Convention to Consider the Questions Involved in Mosquito Extermination" was held in the rooms of the Board of Trade and Transportation, New York City, on the afternoon of Dec. 16. Some comments on the general character and significance of the conference are printed in our editorial pages.

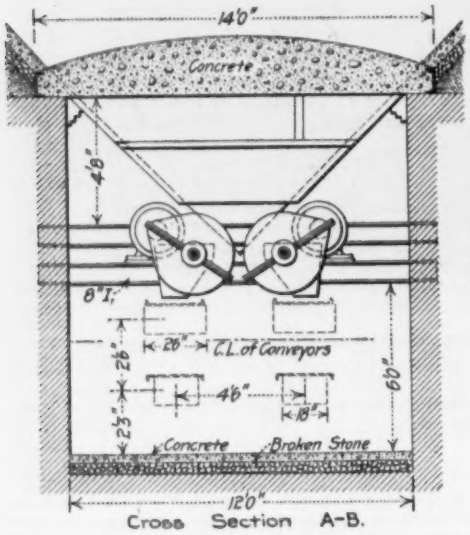
A temporary organization was effected by electing Mr. Robert W. De Forest, Tenement House Commissioner of New York, as President; Mr. Henry Clay Weeks, of Bayside, New York city, as Secretary, and Wm. J. Matheson, described as "the father of the movement on the North Shore, L. I.," as Treasurer. Mr. Weeks calls himself an "Engineer in Economics" and an expert in "Mosquito Engineering." Certainly he has done much to deserve the latter title, and if so, why not the former?

After an opening address by Mr. Weeks, a paper sent in by Prof. John B. Smith, State Entomologist of New Jersey, who is located at Rutger's College, New Brunswick, was read. The paper was on "How a State Appropriation May be Used,"

and described the work done during the past season under the direction of Professor Smith, and by the aid of the first State appropriation for mosquito work ever made in this country. During the past summer seven men were kept in the field, distributed well over the State. A total of 33 species of mosquitos were collected, and 31 of these were bred. One or two more species may yet be found, but it is thought that the mosquito fauna of the State has been pretty fully covered. A small sum of money was spent in experimental ditching for drainage. Professor Smith considered it legitimate for a State to make mosquito surveys and to give general advice, leaving to local communities the work of extermination. Money should first of all be spent in study, so as to avoid the loss of public confidence which would follow mistaken executive measures.



Plan.



Cross Section A-B.

FIG. 10. TUNNEL AND DISCHARGE CHUTES FOR STONE STOCK HOUSE BINS.

Mr. Walter C. Kerr, President of Westinghouse, Church, Kerr & Co., told "What a Rural Community Can Do." The community was on Staten Island, and included an area of some two square miles, embracing both marsh land and upland. In 1898 subscriptions were secured and 25 ponds were covered with petroleum oil. Later the ponds were drained. The oiling was temporarily, the drainage was but permanently effective. The greatest difficulty met was such marsh lands as could not be drained. Plans to exclude sea water from these by tide gates were under consideration when annexation to New York City checked the proposed municipal undertaking.

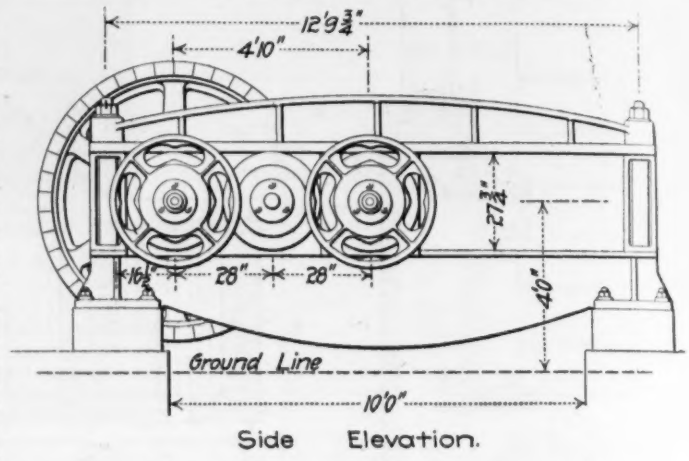
Dr. L. O. Howard, of Washington, D. C., sent a letter outlining "The World-Wide Crusade" now being carried on in or by Great Britain, England, Italy, Japan, Cuba and Mexico. The main incentive for the work in other countries is the prevention of malaria and yellow fever, the United States alone showing great efforts prompted largely by the desire to secure personal comfort. The latter, however, is a worthy motive in sections where vast sums are being expended for luxurious country living.

Several representatives of the U. S. Army and of the U. S. Marine Hospital Service spoke during the conference.

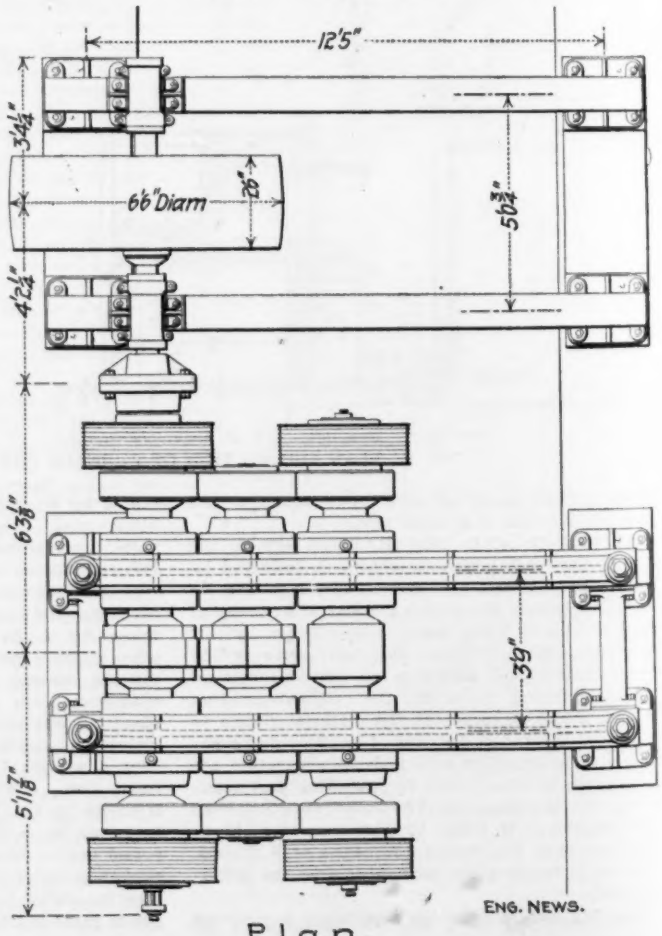
To exclude mosquitos from dwellings and institutions, particularly where malaria or yellow fever are prevalent, windows should be protected by fixed screens and doors by double-screened vestibules. Mosquitos already in a building may be destroyed, if few in number, by the oil cup method, or by a thorough disinfection with sulphur, pyrethrum or hydrocyanic acid fumes. A pound of sulphur or 2 lbs. of pyrethrum will serve for 1,000 cu. ft. of space. The sulphur cannot be used where there are fabrics which might be damaged. The hydrocyanic acid gas will injure nothing except brass or nickel, but moist food should not be exposed to it, nor should fires be left burning. For the acid fumes named, one fluid ounce of sulphuric acid, 2 oz. of water and 1 oz. of cyanide of potassium are employed to each 1,000 cu. ft. of space. This agent will kill ants, cockroaches, bed bugs and other vermin, as well as mosquitos, but the gas is a deadly poison, and must be generated with the utmost caution. Bowls with the liquids named are placed in each room and a stated quantity of the cyanide of potassium, in a bag, is emptied into the bowl, and the door to the room hurriedly closed. Of course, all air passages around doors and windows must be stopped before any system of fumigation is attempted. The hydrocyanic acid gas is an ideal disinfectant for railroad cars, being harmless to the fabrics therein exposed, and being developed, in this case, with but little danger to anyone. Yellow fever patients should be screened to prevent the access of mosquitos.

Mr. Wm. J. Matheson stated that five years ago he bought an estate on Long Island, and on ascertaining the nature of the mosquito problem he began to do away with breeding places. After working four years his place was practically, if not absolutely, free from mosquitos. Among the breeding places were roof gutters out of grade, cisterns, crotches of trees, hoof prints, and springs on a hillside. Larvae were found in a well 110 ft. deep in water at 56° F. The gutters were straightened, the cistern and well screened, hoof prints filled with dirt, and the springs were drained. The work extended to adjacent estates and was taken up by the North Shore Association, all with marked success.

Mr. John Claflin, President of the H. B. Claflin Co., New York City, and of the Morristown (N. J.) Improvement Society, described some interesting work done in or near Morristown. He prefaced his remarks by saying that sunshine seemed to favor the breeding of anopheles, the malaria-bearing mosquito, and that it had been a grief to him to do away with a swamp and pond which were particularly attractive. The swamp gave no trouble until a railway embankment was built through it, increasing the stagnant water, and bringing in, presumably, both anopheles, mosquitos and malarial Italian laborers. Within two years some 25% of all adult persons living within 1,000 ft. of the swamp, previously healthy, were attacked by malaria. Subscriptions were secured, the dam removed, the pond emptied, and the swamp was drained by pipes, supplemented by open ditches where the ground was yet too soft for the pipes. The mosquitos, previously numerous and including anopheles, had almost disappeared from the section, and scarcely an anophele was found during almost weekly inspections last summer.



Side Elevation.



Plan.

Fig. 11. Plan and Elevation of Fine Grinding Rolls.

Mr. Wm. N. Berkeley, M. D., of New York City, read a paper on "The Exactness of Proofs of Transmission of Malaria."

Mr. Wm. J. Baldwin, President of the Lond Island Railroad Co., sent a letter expressing the necessity of work by both individuals and corporations, and stating the willingness of his company to co-operate in the work. He thought that the State of New York should join in the enterprise. Mr. Weeks, who read the letter, remarked that the Long Island Railroad had already done much practical work in the way of both filling and drainage.

Mr. Spencer Miller, Engineer of the Lidgerwood Manufacturing Co., and prominently connected with the South Orange (N. J.) Improvement Society, presented a number of statements designed to show that mosquito pests in any community are largely local in origin, and therefore subject to local control. During the past season the wind was from the marshes towards South Orange, 4½ miles away, on 22 of 123 days, yet the marsh mosquitos were observed on only a very few days. Mr. Clafin remarked, at this point, that such mosquitos as are carried a long distance by the wind are not malarial.

Prof. Milton Whitney, Chief of the Division of Soils, Washington, D. C., sent a letter, in which he pointed out the richness of the soils of swamp lands, and the value of the peat deposits that may be reclaimed by drainage. Much work of this character has been done both abroad and at home, but vast areas in America are still unreclaimed.

Dr. E. Porter Felt, State Entomologist, Albany, N. Y., read a paper on "What New York State Ought to Do." He deemed it essential that practical work, particularly where undertaken on a large scale and when requiring many years' time, should be based on scientific principles. The needs in the vicinity of New York City are the greatest, for within a radius of 25 there are some 200 sq. miles of marsh land, about equally divided between New York and New Jersey. A biological survey of swamp and marsh areas, particularly near the large cities, is needed. The example of New Jersey might be followed and such work entered upon; perhaps in co-operation, so far as possible, with New Jersey. The problem could perhaps be studied sufficiently if there were available for four or five years an annual appropriation of $3,000 to $5,000.

By the time the foregoing addresses had been delivered a late hour had been reached and the audience, which was large at the beginning, was getting small. Among papers yet unread was one on "Mosquito Engineering," by Mr. Henry Clay Weeks, "Engineer in Economics, Bayside, City of New York," to whose efforts the conference was largely due.

Mr. Weeks has kindly supplied us with a statement giving the gist of his paper, as follows:

Mosquito extermination is essentially an engineering problem. Other features of the work are highly important, but the engineer may best determine and carry out plans to get rid of the breeding places, often involving the redemption of thousands of acres of marsh or saturated areas of vast value. Heretofore engineering has been for and not against the mosquito. Breeding places have almost universally been caused by engineering works. This applies to highway, railroad and landscape engineers. The result has often been the depopulation of valuable sections by malaria and its bearers, the anopheles. The better term is "economic engineering," for the work covers a wide range besides simple extermination—the utilization of large areas for agriculture and even for habitation, and the improvement in living conditions of a vast population.

During the conference a resolution was adopted providing for a committee of ten, to be named by the chair, to consider and report on permanent organization, the committee to have power to promote legislation, to arrange for the publication of the proceedings of the conference, and to call another conference whenever it should see fit.

FIG. 12. SWINGING SCREW CONVEYOR IN RAW MATERIAL STORE HOUSE.

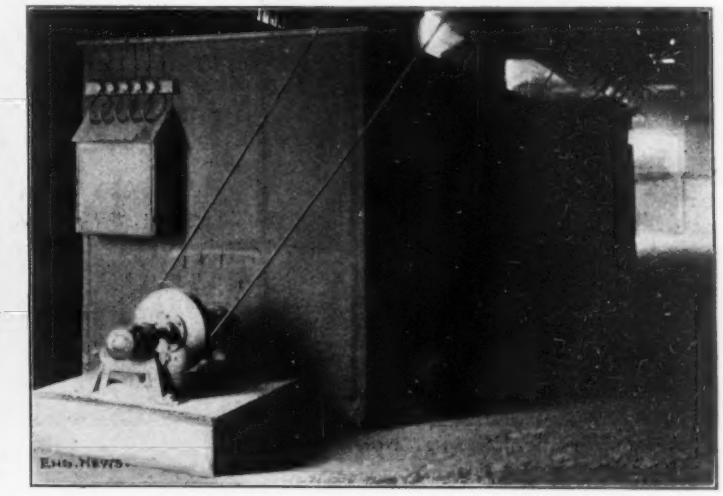


FIG. 16. VIEW OF EXTERIOR OF HOUSING FOR ELECTRIC MOTOR WITH WALLS OF BURLAP TO EXCLUDE DUST.

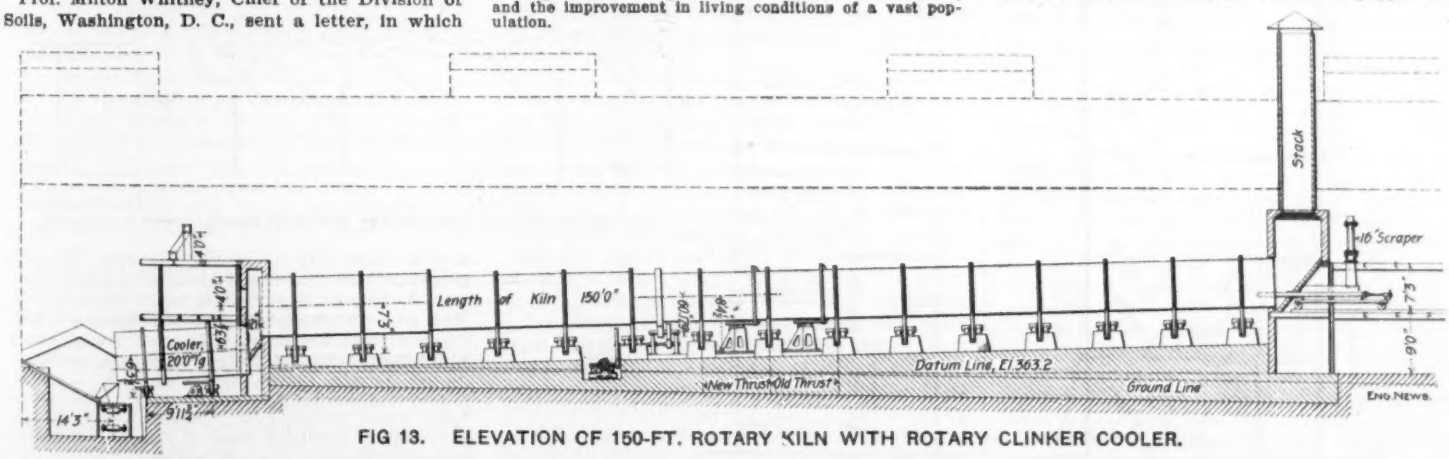


FIG 13. ELEVATION OF 150-FT. ROTARY KILN WITH ROTARY CLINKER COOLER.

A NATIONAL LAW FOR THE COMPULSORY ADOPTION OF BLOCK SIGNALS.

A notable feature of the annual report of the Interstate Commerce Commission, of which advance proofs have just been made public, is the recommendation that the United States should follow the lead of England and make the use of the block system in railway operation compulsory. After reviewing the year's statistics of railway accidents in considerable detail, the commission continues as follows:

The most prominent fact in this year's record of train accidents is the appalling loss of life and property in collisions. The showing can not be called materially worse nor materially better than that made a year ago, and the total number of passengers killed and injured does not differ from the record of the preceding year to such extent as to call for comment; but the mere continuance of the record, though it be no worse than in former years, is a disgrace to the American people, painful to every careful observer.

That 130, or 118, or any large number of passengers are killed in the United States in the course of a year in a single class of accidents indicates a condition which should not pass without serious attention. These fatalities are due to causes which have never been adequately considered by any department of government, either of the United States or of any of the states, and there is a crying need for such consideration. Railroad accidents, their causes and their results, have been considered in judicial decisions, and in the deliberations and verdicts of coroners and coroners' juries, and to a very limited extent by state railroad commissions, but none of these have dealt comprehensively with the subject, and apparently no improvements in railroad service nor reformatory measures of any kind have resulted from such action.

THE BLOCK SYSTEM; DESIRABILITY OF ITS INTRODUCTION.—That many railroads have equipped some of their lines with block signals, a measure which greatly reduces the chances of collisions, is a gratifying fact. Some important railroads do not use the block system. Most companies adopt it on parts of their lines but not on other parts. Some use it part of the time or for some of the trains. Some adopt the principle, but have insufficient regulations. There occurred in the United States in the year under review an enormous number of collisions, 5,219, and (included in these) 10 collisions in each of which 7 or more persons were killed (104 persons in the 10 cases).

So far as we can see, the best thing to do is to introduce the block system. That is what England has done, and the immunity from collisions on English railroads is so nearly complete, and the casualty records so low, as to be a powerful argument for its adoption. The commission therefore recommends the consideration of a law like that in force in Great Britain and Ireland, requiring the adoption and use of the block system in the United States,

unless some better device can be secured. A tentative draft of a bill for that purpose is given in the appendix.

This proposed bill has been drafted on the theory that the expense necessary for the construction of new signals, or for electrical wires or apparatus necessitated by the use of the block system, as well as the increase in the expense for wages of signalmen should be distributed over a term of years; and it is proposed, therefore, that each railroad company be required to adopt a block system on one-fourth of its passenger lines by Jan. 1, 1906; on another fourth by Jan. 1, 1907; another fourth one year later, and on the whole by Jan. 1, 1909. Many of the principal lines would be required to make no important additions to their expense accounts for the first two years, and some would feel no burden for the first three years.

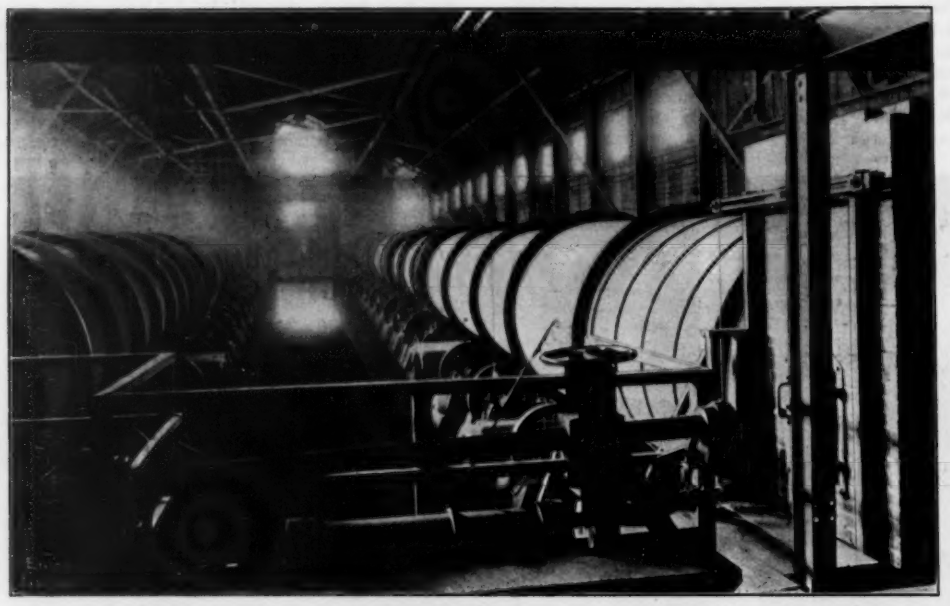


FIG. 14. VIEW ALONG KILN HOUSE, SHOWING 150-FT. ROTARY KILNS.

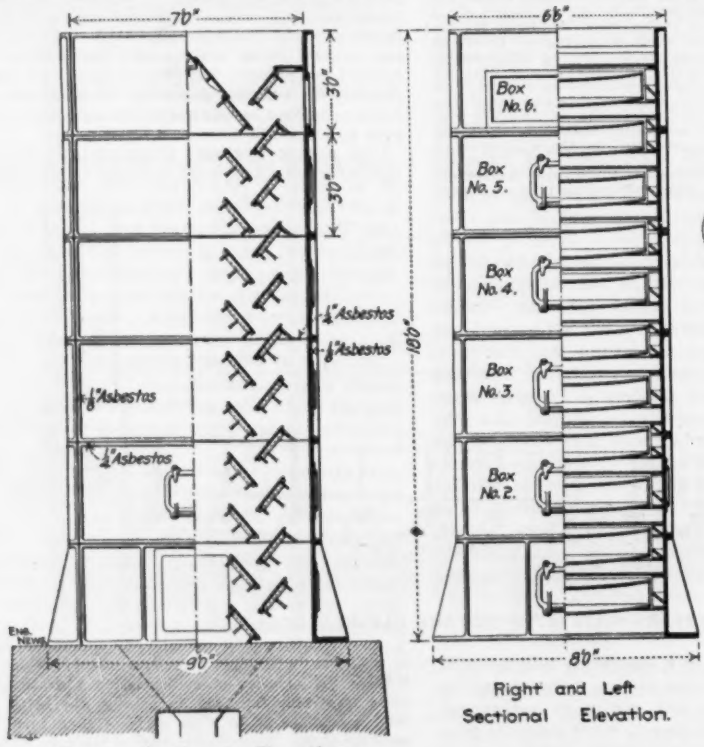


FIG. 15. DETAILS OF STACK DRYER FOR COAL.

For the purpose of dealing with separate parts of an extensive system of railroads a section has been included, enabling the commission to deal with one part of a company's line independent of the other parts.

VALUE OF BLOCK SYSTEM CONCEDED BY RAILWAY MANAGERS.—In view of the frequency of startling accounts of railroad disasters that have been laid before the public in the newspapers within the last few months, there can scarcely be need of argument. If any argument is needed in favor of the proposition to take legislative action looking to the prevention of these horrible disasters, which the most enterprising companies make for scientific and vigilant oversight of their signaling plants.

DEFECTS OF ORDINARY METHODS INCURABLE.—The fact is that defects in the ordinary methods of managing trains must be looked upon as incurable. Either from ineradicable mental infirmities in men of the most competent class, or from the employment of men more or less incompetent, collisions, due to blunders and forgetfulness, usually of two or more men simultaneously, follow one another in endless and rapid succession. Only about one-seventh of the railroad mileage of the country is worked by the block system, and the strong arm of governmental authority is needed to arouse those companies which have not taken action, or which have made progress so slowly that they are chargeable with neglect of a plain duty to the public. The proposed act, or some measure of similar character, is therefore earnestly recommended to the attention of the Congress.

STRESSES IN THE CONCRETE ARCH OVER BIG MUDDY RIVER; ILLINOIS CENTRAL R. R.

In the article on the Big Muddy Concrete Arch, by Mr. H. W. Parkhurst, Engineer of Bridges and Buildings of the Illinois Central R. R., in our issue of Nov. 12, a table of the pressures, at the several voussoir joints of the arch, was omitted from the strain sheet. We have received requests from correspondents for the data given in this table, and therefore print it herewith.

Inquiry has also been made as to why steel reenforcement was not used in the main arch. In reply it may be stated that the use of steel reenforcement was considered and some estimates were made upon it. It was, however, abandoned partly on account of the expense involved and partly because of the delay which would have at the time been necessary before the steel could have been procured.

PRESSURE ON VOUSSOIR JOINTS OF BIG MUDDY ARCH.

(Weights assumed as follows: Concrete, 140 lbs. per cu. ft.; ballast, 100 lbs. per cu. ft.; track, 420 lbs. per ft. of length; live load, 6,125 lbs. per ft. of track, fully loaded; live load, 6,675 lbs. per ft. of track, half loaded.)

Joint.	Pressure, lbs.	Pressure — Average — Tons pr sq. ft.	Average — Lbs. pr sq.in.	Maximum — Tons pr sq.ft.	Maximum — Lbs. pr sq.in.
	Arch Fully Loaded with Live Load.				
1	240,188	24.01	333.60	46.80	650.11
2	240,626	23.65	328.94	43.46	603.64
3	242,500	22.55	313.30	33.03	458.75
4	243,750	21.19	294.37	25.81	358.57
5	247,500	19.80	275.00	22.84	317.23
6	253,750	18.38	255.39	23.83	331.04
7	256,876	16.05	216.01	25.56	355.10
8	267,500	14.08	195.57	21.46	298.07
9	265,626	11.06	153.71	14.27	198.30
10	263,750	8.24	114.47	11.95	165.98
	Opposite Half Loaded with Live Load.				
1	246,020	24.60	341.69	49.10	682.02
2	246,250	23.22	322.62	48.24	670.06
3	247,500	23.02	319.76	43.49	604.15
4	247,500	21.52	298.90	38.62	536.50
5	250,000	20.00	277.77	39.08	542.84
6	253,750	18.38	255.39	37.48	520.56
7	253,750	15.82	219.75	33.06	459.30
8	260,000	13.60	190.05	32.31	434.93
9	253,750	10.57	146.84	13.39	186.00

UNIFORM MUNICIPAL ACCOUNTING has received a new impetus, it is believed, through the recent conference on the subject at Washington, held under the auspices of the U. S. Census, of which Mr. S. N. D. North is now director. At the conference named there were representatives of national, state and municipal governments and of voluntary associations interested in the movement. A national advisory committee to consider and promote reforms in municipal accounting, including measures to secure greater uniformity, was appointed, as follows: L. E. McGann, City Comptroller, Chicago; Edward M. Grout, City Comptroller, New York; Harry B. Henderson, State Examiner of Accounts, Cheyenne, Wyo.; John R. Sparrow, Supervisor of Public Accounts, New York City; Dr. Edward M. Hartwell, Secretary Statistics Department, Boston, Mass.; Joseph T. Tracey, Deputy in the State Bureau of Uniform Accounting, Columbus, O.; Geo. Forman, Auditor, Newark, N. J.; H. L. Austin, State Comptroller's Office, Albany, N. Y.; Allen Ripley Foote, Editor "Public Policy," Chicago; Harry T. Upham, Auditor, Cambridge, Mass. It is hoped that another general conference will be held in 1904.

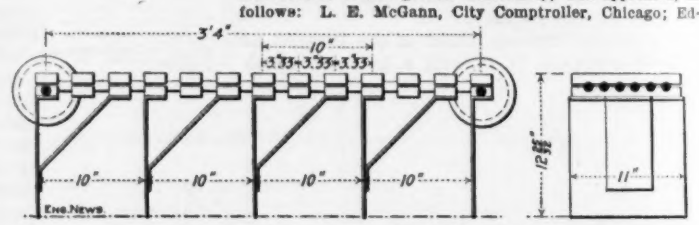


FIG. 16. SCRAPER CONVEYOR WITH SLIDING SHOE CARRIERS.

THE PRACTICAL WORKING OF TRENCH EXCAVATING MACHINERY.

By Ernest McCullough,* C. E.

Within the past two years several trenching machines of more or less merit have come into use. The dearth of labor, caused more by the extraordinary artificial advance of wages than by the large amount of construction work, has largely been responsible for this. The writer has at times had difficulty in securing labor when idle men were plentiful, and the cause was high wages. The requirements of common labor, so far as the necessities of life go, are small. When by reason of unions or such combinations the pay is raised

*Engineer Municipal Engineering & Contracting Co., Manhattan Building, Chicago, Ill.

to a point where a man earns easily more than he needs, the tendency is to put in less time at work. Such conditions lead men to seek for machines capable of doing the work. The laboring men, therefore, have only themselves to blame if an employer exhibits a preference for machine labor when he finds machines capable of supplanting hand work.

Contractors engaged on municipal work are such great sufferers from the uncertainty of the labor market that the business is becoming a great gamble. The most carefully figured job often shows a decided loss when completed.

On this class of work, therefore, new machines are continually being tried.

In the digging of trenches for the drainage of lands, and for laying sewers and water pipes in city streets, dozens of machines have been tried and have either been absolute failures or too uncertain in operation to prove satisfactory. Yet the search goes on for a good machine for this class of work, and lately with some degree of success.

In the article on Agriculture in the "Encyclopedia Britannica," a tile-laying machine is described, and several modifications of this machine have been tried in many places. The writer, while draining some alkali land the past spring in the state of Washington, used one made by R. P. Tjössem, of Ellensburg, Wash., but had poor success. In soft soil the machine was successful, and many hundreds of acres have been successfully drained with the use of this machine. In the land drained by the writer many streaks of hardpan were encountered, and the machine could not be used.

The machine was something like a subsoil plow. A beam of heavy timber 12 ft. long had under the forward end a pair of broad wheels, and at the rear end a stem of steel 4 ft. long and about an inch thick. On the lower end of this steel stem, which had a sharp front edge, was a steel shoe like a subsoil plow point. A hole was dug in the ground and the stem let down until the beam was parallel with the surface of the ground. About 300 or 400 ft. ahead "dead men" were planted to anchor a drum carrying a cable from the plow. Horses were used to wind the cable and pull the plow forward. The stem cut through the ground and the plow point pressed back the earth and made a hole through the soil. By an ingenious device, a small following cable was attached to the point and carried the tiling, or wooden boxes, after it. When 300 ft. had been laid, the following cable was automatically released and withdrawn. The "dead men" and drum were moved ahead and another 300 ft. was put in.

Owing to the impossibility of using this blind ditcher in any but soft ground with a firm sod, Mr. Tjössem went to work on a machine with chain and buckets to excavate. The writer commenced to look into the subject and found such machines to be already in use. Of these the Buckeye wheel machine, described in Engineering News of Aug. 6, 1903, and the machines made by the Municipal Engineering and Contracting Company of Chicago seemed to possess the most merit and in the smaller sizes are very similar. Since entering the employ of the latter company, he has had an excellent opportunity of seeing such machines at work under most adverse conditions, and is convinced there is a great future for them. Longer use will develop improvements, but all machines can be improved.

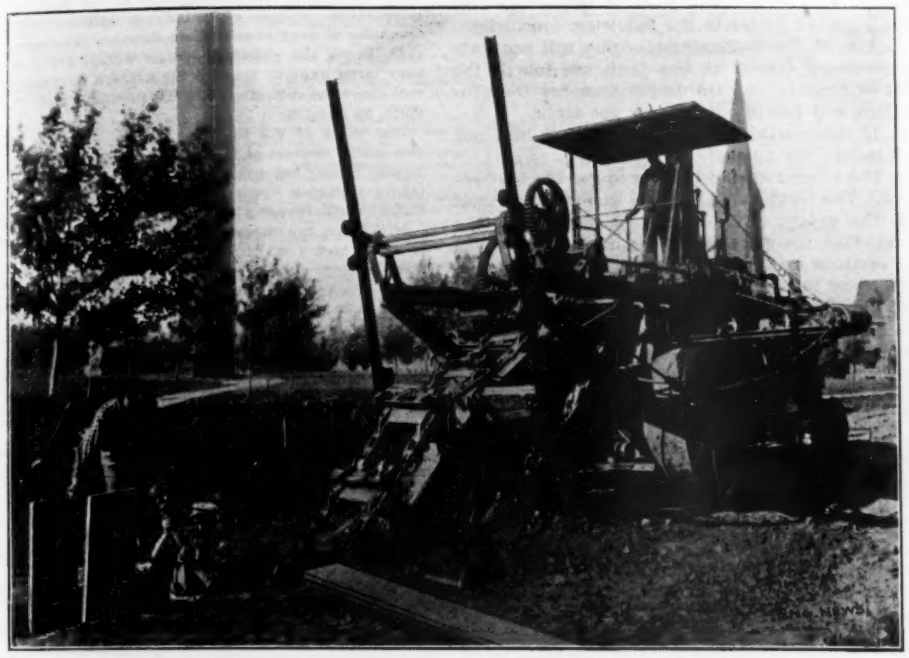


FIG. 1. THE AUSTIN TRENCH EXCAVATING MACHINE IN OPERATION.

The wheel machine has shown in use that conditions must be extremely favorable and a limit in depth of 6 ft. seems the most economical. For greater depths a chain with plows and cutters is best. The Libby bucket machine (described in Engineering News of Aug. 6, 1903), works on an entirely different plan.

These chain and plow machines were developed by Mr. J. H. Bentson, a mechanical engineer in the employ of the F. C. Austin Mfg. Co., and Mr. F. C. Austin organized a company to manufacture and lease the machines, as they are too costly for the average contractor to purchase. The company bids on sewer contracts, and if the whole contract is not secured, endeavors to sub-contract for the trenching. Twenty-two machines are now at work, and as the company has plenty of capital to push them, their use is increasing.

The illustrations give an excellent idea of the large machine, capable of cutting a trench 16 ft. deep. By the addition of an extension a further depth of 7 ft. can be secured, so that a 23-ft. trench can be dug if necessary. In the right kind of soil another 7 ft. can be added, making 30 ft. in all. As the machine works best when the excavator works at an angle greater than 30°, deep trenches may cost less than shallow ones. This machine cannot compete with hand labor on trenches less than 6 ft. deep, but for such shallow trenches smaller machines are made.

At Neenah, Wis., last year, the company dug about five miles of trenches. It encountered many difficulties, but made money on its sub-contract notwithstanding. In Indianapolis three machines are leased. In St. Louis a contract is now under way for about 16 miles of pipe and brick sewers. This is a direct contract. The writer was put in charge first of the Marshfield, Wis., contract of about 7½ miles of sanitary sewers, and over one mile of outlet, afterward going to St. Louis.

The machines are not yet perfect, but they are money-makers, albeit subject to the breakdowns and stoppages incident to machinery in general. Every new machine turned out embodies improvements suggestd by men in charge in the field, and it is gratifying to record that these improvements are noticeably less numerous than at first.

The daily cost of operation is as follows:

	Operator	$3.00
	Engineer	2.75
	Fireman	2.25
	Trimmer	2.25
2	Plankmen (bracing)	4.00
2	Pipe layers	5.00
1	Pipeman	2.00
2	Tampers	4.00
1	Shoveler	2.00
2	Teams and drivers	7.50
4	Scraper holders	8.00
	Total	$42.75

The machines have cut 750 lin. ft. of trench in ten hours. This is close to the limit of the ability of the pipe-layers to lay pipe. They are seldom more than 20 ft. behind the machine. Such runs can seldom be made, however, as water pipes and other obstructions cause delays.*

With long runs, and also with deep trenches, additional teams and scraper-holders are employed, for an endeavor is made to cover the trench so that when the day's run is complete the pipe is covered and all dirt back in the trench close to the machine. The depth of trench makes practically no difference in speed, but a very shallow ditch may cause a greater coal consumption, as the small angle at which the excavator trails may cause it to bind and also increases the friction. An ordinary day's work with clear running is from 400 to 500 ft.

The machine pulls itself ahead by a cable attached to deadmen. When moving to another block it travels as a traction engine, the excavator being lifted (as shown in Fig. 2). It takes only a short time to move from one street to another.

While the wages of the operator and engineer seem small as compared with the other men, such is not really the case. These two men are sent from the company shops and make full time. The other men lose rainy days, etc.

In St. Louis and other large cities gas and water connections come about every 25 ft. Men go ahead of the digger removing the pavement the width of the trench. After them follow men who cut the house connections at each side of the ditch and take out a section of pipe, capping the ends. When the machine passes they replace the piece taken out, which in the meantime has been threaded. The speed of the machine being from 40 ft. to 60 ft. an hour, no house is cut off longer than an hour or so. The real things which govern the speed are the number and kind of house connections and the size of the pipes laid, small sewers being handled more readily than large.

Sometimes it is awkward to start the machine from the lowest point and work up, as, for example, where two spurs meet at a manhole. At such places the pipe is laid backward, in one spur, the machine going straight through. In laying pipe backward three lengths are always fitted and graded. Then one is cemented, two being drawn out for that purpose, the next one put in place and another fitted. These are drawn out to fit the upper one and in this way the bells are pushed over the ends of the higher pipes and the pipes laid carefully to grade with no disturbance of joints after the cement has been put in. It is about 20% slower than the ordinary way, yet a time saver. Ordinarily the machine would cut the trench to the manhole. All the crew then would be idle except the three men with the machine, and possibly the plankman. When the lower end is reached and the pipe-laying commences from the lower end the machine with its crew is idle until the pipe-laying is completed. Being able to follow the machine makes the back-laying of pipe quite an economy.

The trimmer is the man who grades the trench bottom accurately to line behind the excavator. He throws the dirt on the foot of the excavator and it is carried up by the scrapers. His duties

*In Marshfield, Wis., on one clear run in a dry clay one of the machines cut a trench 7 ft. deep and 815 ft. long in ten hours. No stones were encountered. The same machine on the last run cut 486 ft. in 4½ hours. The trench was 5 ft. deep at one end and 9 ft. at the other. No stones were found in this trench. On Nov. 10 the other machine on a timed run made 100 ft. of 7-ft. ditch in 47 minutes. Its record that day was 486 ft. in 9 hours. Several stops were made to blast small boulders.

are light, for the machine follows a grade very nicely. One man follows the pipe-layers and tamps the earth around the pipe nearly to the top, the shoveler throwing dirt from above for the purpose.

The backfilling is generally done by scrapers, the horses pulling from the other side of the ditch, a long rope or chain being attached to the scrapers. After it is filled and all the earth mounded up a hose is run into the trench and the earth well wet. A street roller and street grader go over it alternately and soon get the street into shape.

When the street is comparatively narrow and lawns and sidewalks suffer from the banked-up earth dump wagons have been used precisely as with the New Era graders. They pass under the conveyor to get the dirt and then go across the end of the fill, dumping as the trench is crossed. In St. Louis the machines (three) cut faster than teams could handle the earth and shutdowns were frequent, while waiting for the scraper work to get caught up. Only a certain number of feet of trench could be open at one time, and teams are scarce in the World's Fair city this year.

A scraper attached to a hoisting engine was used with some degree of success, but the backfilling conveyor is solving the problem. Only one has been made and put to use so far. It travels alongside the machine and has a separate engine receiving steam through a hose from the main boiler. The conveyor is 78 ft. long and carries a traveling belt 4 ft. wide. The excavated earth

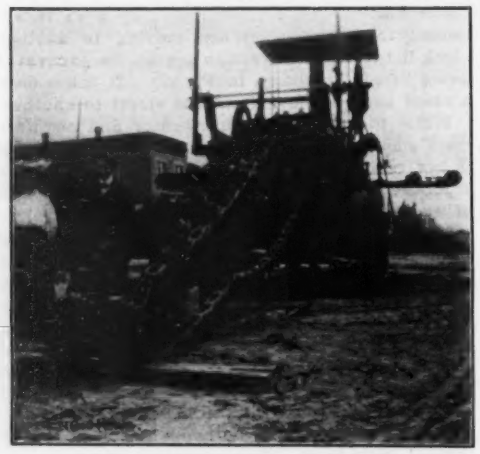


Fig. 2. Austin Trench Excavating Machine with Cutter Raised for Movement Ahead.

is thrown on the belt and carried to the end, where a slight angle and tilt on the frame causes the dirt to go into the trench. Thus it never touches the surface of the street.

In St. Louis the machine successfully cut about 300 ft. of reverse curve with 100 ft. radius. It took careful placing of deadmen and caused a severe strain on the excavator, but the curve in the street made it necessary.

Boulders are frequently encountered. If small they cause no trouble. If large the excavator is raised and the stone cracked with dynamite in small charges. The excavator is dropped again and the stones brought out with the earth regularly excavated. The raising and lowering of the excavator being all done from the machine by means of levers and wheels, the operation requiring little time.

In Marshfield, Wis., an old, buried and forgotten corduroy road was struck a few feet below the surface. There was nearly half a mile of it. The logs were from 8 to 14 ins. in diameter. Sharp new plows and cutters on the chain caught in the wood, so dull ones had to be used. Logs close to the surface were pulled out by the machine, but those deep enough to be held by the earth were chewed through without trouble like beaver-felled trees. The cutting of the trench through the corduroy will never be forgotten by the Marshfield people.

On the part of the street where the main sewer, of 15-in. and 10-in. pipes, was laid, an old box sewer was encountered at less depth. Although the wood was old, some was pretty sound. The machine chewed this old sewer up and spat it on the bank along with the earth.

To say the machine did not suffer from these two experiences would be drawing the long bow. The effects were bad and parts were unduly strained and permanently weakened. Yet the machine was not sent to the shop for repairs, and is still at work. To go through a 2-in. gas or water pipe is easy, and happens often, but 14-in. logs are bad, and it is a big test—one which the inventor and the makers would not willingly ask.

Considerable experience with these machines, coupled with information received concerning others, leads the writer to the following conclusions:

1. A good trench-digging machine will excavate an ordinary trench at less than one-fourth the cost of hand labor. On deeper trenches the proportion will fall to one-fifth or one-sixth.

2. If the weather is unfavorable it is best not to attempt too much.

3. The ground should be firm to get the best results. The tougher the clay the easier the cutting.

4. The weight of the machine being close to the excavation, the vibration of the machinery causes the earth to settle more or less. It is therefore a safe thing to plank all trenches.

5. For the above reason sandy soil and gravel are hard to work in. The machine goes too fast for men to plank readily.

Objections 4 and 5, however, will in the near future be removed.

6. The machine is best adapted for pipe sewer work. The construction of brick sewers is too slow, unless the trench can be excavated several hundred feet ahead and left open a long time.

7. No machines have yet been brought to a state of perfection so far as trench work goes. It is therefore necessary to look over the ground carefully before deciding upon their use. Under favorable circumstances they are such an advance over hand labor that their use will continually increase.

The writer's absolute knowledge of work done by trench machines of this nature and class is confined to the machines made and used by the company employing him. He has seen no others, and may, therefore, be justified in the light of his present knowledge in stating them to be thoroughly practical, as proven by actual tests and possibly the best of their kind at present in existence. Under the right kind of management they certainly are a credit to the inventor. The essential working parts will probably undergo in the future little or no change. It will simply be a matter of the improvement of small parts and details. Special designs for special work will no doubt appear when needed.

An interesting problem arose in the handling of a trench where considerable quicksand appeared. It was solved by driving two lines of sheet piling ahead of the machine to a depth of 1 to 2 ft. below the sewer depth. The machine cut between these lines and the trench braces were quickly put in as the machine passed. This was an exceptional case. Generally it will be best to avoid using the machines in soil where quicksand is encountered, although they can be used if circumstances compel.

THE DEVELOPMENT OF THE GROINED ARCH ROOF IN ENGINEERING STRUCTURES IN THE UNITED STATES.*

By Leonard Metcalf, Assoc. M. Am. Soc. C. E.†

The writer has ventured to supplement his discussion of Mr. Fuller's paper‡ by certain additional data which may be of interest in bringing information down to date, and as being of historical value in the study of the development of the groined arch roof in engineering structures in the United States. In this he has been materially assisted by contributions from Mr. Charles Hermany of Louisville, and Mr. Allen Hazen and Mr. John H. Gregory of New York, who have furnished him with new material and have kindly consented to the publishing of some of the interesting facts mentioned by them relating to the construction of plants designed by them.

In comment upon the (accompanying) table one or two facts should be mentioned. The "Mean Thickness of Roof, Inches," is figured on the basis of the amount of masonry above a horizontal plane passing through the springing line of the roof arches and contained within the area covered by pier units. No account is taken of the masonry in the pier below this plane or of the masonry in the floor. No allowance is made for the increased amount of masonry used in the barrel or the cloistered arch along the walls surrounding the area covered by pier units, as the pier unit area was thought to be the better unit of comparison. Neither was allowance made on account of manholes or sand runs. These elements (manholes, sand runs, barrel and cloistered arches) will be found in ordinary large units to increase the average thickness of the roof above the springing line, as determined from the pier units, by about ½ to 1½ ins.

The "Cost of the Roof per Square Foot" in general covers only the cost of the masonry, including therein materials, labor, centering and removing centering, etc. (above springing line of roof), but does not include the cost of earth covering and of engineering.

In the last two columns has been computed a function of those arches which have been built, a function that many engineers must have noticed, though so far as the writer knows, Mr. Hazen was the first to specifically allude to it in a letter to him dated Oct. 6, 1903. In this Mr. Hazen writes:

> In your table of vaulting there is one point of some interest to me, namely, that the circle having the same curvature as the ellipse at the top, the radius of which is obtained by squaring the span and dividing by the rise, is, for all figures listed in your table, somewhere nearly a constant, at least it varies a good deal less than any of the other dimensions do. This indicates approximately a constant thrust and a constant strength of vaulting per square foot of area when it is computed acting entirely as an arch.

This relation, which, briefly, consists in finding the radius of a circle passing through the crown and the springing lines of the elliptical groined arch, is of course one long known to railroad engineers, who have made use of the approximate formula,

$$\text{Middle ordinate.} = \frac{\text{Chord}^2}{8 \times \text{Radius}},$$

from which by transposition, we have the

$$\text{Radius} = \frac{\text{Square of Span}}{8 \times \text{Rise}}.$$

This value, figured by the writer and shown in the left of the two columns mentioned, led the writer to compute the more exact value of this radius from the relation of similar triangles, which gives the formula,

$$\text{Radius} = \frac{(\text{Chord of semi-span})^2}{2 \times \text{Rise}} = \frac{(\text{Semi-span})^2 + (\text{Rise})^2}{2 \times \text{Rise}}.$$

While both of these values are empirical, for the arches have generally been segmental, not elliptical, they are of interest and serve as guides to judgment in design. The average value of the radius, shown in the right column, as determined by omitting the Louisville arches (which contained embedded steel) and the New Milford, N. J., arches (which have an abnormally heavy superimposed load, a mechanical filter plant) is found to be,

$$R = 9.17 \text{ ft.},$$

while the extremes of conservative and radical practice (though in the writer's opinion the radical class of to-day will become the conservative class of the next decade), show approximate values of R = 8.5 and R = 10 ft.

Mr. Hazen writes in regard to the Albany filter roof:

> I see at Albany the extrados is marked parabolic. This was true of the outside and cross-walls, but the depression over the piers was made conical. The cone, however, did not start exactly at the summit, but at such a point as not to reduce the thickness of the arch below 6 ins., and in fact the minimum due to the cone was a little more than this figure. From my final estimates the volume of the depression was 25.219 cu. ft. The volume equal to a square 6 ins. thick was 93.389 cu. ft., and the volume of the vaulting from the pier up to the bottom of the 6-in. slab was 64.055 cu. ft., making the exact volume over each pier 132.235 cu. ft., which corresponds to a thickness of about 0.71 ft.
>
> Another computation which I made Feb. 9, 1899, gives:
>
> | | |
> |---|---|
> | Reduced thickness of vaulting over piers in filters | 0.71 ft. |
> | Over piers in pure water reservoir (no depression) | 0.84 " |
> | Outside walls | 0.81 " |
> | Cross walls | 0.90 " |
> | Other cross walls | 0.83 " |
> | Outside corners | 1.06 " |
> | Inside corners | 1.54 " |
> | Manholes (distributed over whole area) | 0.029 " |
> | Sand runs, about 0.5 ft. extra over gross area of same. | |
> | Average thickness of vaulting, including all extras on net area | 0.77 " |
>
> I see that in discussing your paper on vaulting I gave the reduced thickness as 0.78. This latter computation was made some months later and I do not find memoranda of it, but I do find that the total quantity of concrete in the vaulting as allowed in the final estimate overran the amount which I estimated in my computation of Feb. 9, 1899, by about 1%; so that the figure given, namely, 0.78, is apparently the correct one.
>
> Apparently this was the first time that the depression over the piers was used, and I do not think it occurred to us to make it parabolic. We did make some designs for curves, but my recollection is that we thought the conical surface would be a good deal easier to build and would accomplish substantially the result to be reached, as well as a curved surface.

*Written discussion, supplementing the author's oral discussion of the paper mentioned in the second note following this one. This discussion will be published in a future issue of the "Journal of the New England Water-Works Association."

†Consulting Civil Engineer, 14 Beacon St., Boston, Mass.

‡"Covering the Natick Reservoir with a Concrete Roof." By F. L. Fuller, M. Am. Soc. C. E., 12 Pearl St., Boston, Mass. An abstract of Mr. Fuller's paper was published in the report of the annual convention of the New England Water-Works Association, which appeared in Engineering News for Sept. 17, 1903. The table herewith, in an earlier and less complete form, was published in the report just named.—Ed.

FACTS RELATING TO GROINED ARCHES COVERING RESERVOIRS AND FILTER BEDS IN THE UNITED STATES.
(Compiled by Leonard Metcalf, Assoc. M. Am. Soc. C. E. Boston, Mass.)

Date	Location	Engineer	Description	Depth of earth cover-ft.	Concrete Arch: Mixed	Span Ft. in.	Rise Ft. in.	Crown Thickness in.	Depression over pier inches	Pier Section at springing inches and area sq. ft.	Volume saved by depression in cu. yds. per sq. ft. depth in ins.	Mean thickness of roof inches	Cost per Sq. Ft. dollars	Pier Load tons per sq. ft. above springing line: concrete at 150 lbs. brick at 130 lbs. earth at 100 lbs.	Impounded Ft.	Impounded Ft.	Notes.
1895	Ashland, Wis.	Wm. Wheeler	Filters net area ½ acre. Intrados ellip., extrados plane. 2 layers flat brick backed with Portland cement concrete.	2'-0"	1:2½:5	15'-9"	3'-6"	6"	none	28 x 23 = 4.42. 28½ x 24 = 4.73 brick	none	11.7		12.5	8.9	10.6	① Cost: column, dovetail masonry only from springing line of arch.
1896	Somersworth N.H.	Wm. Wheeler	Two filters total net area ½ acre. Intrados elliptical extra. plane. 1 layer of brick on edge backed with concrete.	2'-6"	1:2½:5	16'-0"	4'-0"	6"	none	34½ x 34 = 8.15 granite	none	13.	0.47	9.7	8.0	10.0	Earth cover and grading not included unless so stated.
1897	Wellesley, Mass.	Freeman C. Coffin	Reservoir 80' int. diameter. Intrados elliptical ext. plane.	2'-0"	1:2½:5	12'-0"	2'-6"	6"	none	24" x 24" = 4.0 brick	none	10.3	0.225	8.9	7.2	8.5	
1898 Finished 1900	Louisville, Ky.	Chas. Hermany	Reservoir 154,739 sq. ft. net area. Concrete reinforced with steel. Intrados and extrados segmental.	6"	1:2:4	19'-0"	3'-9"	6"	27.6	Dia. 3.4' = 8.0	5.45 = 3.7	11.7	0.61 ②	5.8	(11.9)	(13.8)	② Earth cover etc. inside total excludes engineering only (0.2¢) and test steel reinforcement.
1899	Concord, Mass.	Leonard Metcalf	Sewage Reservoir 57' int. D. Intra. ellip. extra. plane.	2'-6"	1:2:5	12'-9"	3'-0"	6"	none	24" x 24" = 4.0 brick	none	11.0	0.38	11.7	6.8	8.3	
1899	Albany, N.Y.	Allen Hazen	Filters. 8 beds of 0.7 acre ea. Intra. ellip., extra. conical	2'-0"	1:3:5	11'-11"	2'-6"	6"	6"	21 x 21 = 3.06 brick	0.93 = 1.63	8.5	0.182 0.277 ③	11.0	7.1	8.4	③ Incldg. filling main trench etc. but excldg. engineering.
1899	Clinton, Mass.	F. P. Stearns	Sewage Reservoir 100' int. D. Intra. ellip., extra. plane.	4'-6"	1:2½:4	12'-0⅝"	2'-6"	12"	none	30 x 30 = 6.25 25 x 25 = 4.33 brick	none	16.8		12.2 17.7	7.3	8.5	
1900	Superior, Wis.	Allen Hazen	Filters & Reservoir, total net area ½ acre, conical.	2'-0"	1:3:5	12'-0"	2'-6"	6"	6"	20 x 20 = 2.77 brick	0.93 = 1.63	8.4	0.29	12.0	7.2	8.5	
1901	Philadelphia Pa. Lower Roxborough	John W. Hill	Filters 5 of 0.537 acre each. Also filtered water basin 153 x 190'.	2'-0"	1:3:5	14'-0"	3'-0"	6"	21"	22 x 22 = 3.36	2.7 = 3.5	7.3		13.3	8.2	9.7	
1902	Milford, Mass.	Leonard Metcalf	Filters 2 of ⅛ acre each. Intra. ellip., extra. parabolic.	1'-6"	1:2½:5 1:3:5	14'-0"	3'-0"	6"	18"	24 x 24 = 4.0	2.37 = 3.0	7.9	0.36 ④	9.8 16.8 ④	8.2	9.7	④ Cost per sq. ft. least from large area, contr. prices less (poor management)
1902	Philadelphia, Pa. Upper Roxborough	John W. Hill	Filters 8 of 0.7 acre each. Also filtered water basin 236 x 318'.	2'-0"	1:3:5	14'-0"	3'-0"	6"	21"	22 x 22 = 3.36	2.70 = 3.5	7.3		13.3	8.2	9.7	⑤ Including sand stored upon roof
1902	Natick, Mass.	Frank L. Fuller	Reservoir. Intra. ellip. extra. plane.	2'-0"	1:2:4½"	13'-6"	2'-9"	6"	none	20 x 20 = 2.77	none	10.4	0.40	15.1	8.3	9.7	
1903	Ithaca, N.Y.	Allen Hazen	Coag. Basin and Reservoir. Intra. ellip., extra. parabolic.	2'-0"	1:2½:4½" Ibbl. 9 c.f. 17	10'-6"	1'-6"	6"	10¼"	18 x 18 = 2.25 17 x 17 = 2.01	0.75 = 1.70	6.78		10.9 & 12.2	9.2	9.9	
1903?	Proposed for Lawrence, Mass.	Morris Knowles	Filter. Intra. ellip. extra parabolic.	3'-0"	?	13'-2"	2'-9"	6"	18"	22 x 22 = 3.36	2.08 = 3.0	7.5		15.6	7.9	9.2	
1903	Yonkers N.Y.	Allen Hazen	Reservoir Intra. ellip., extra parabolic.	4'-0"	1:2.9:5	10'-0"	1'-6"	6"	9¾"	16½ x 16½ = 1.96	0.65 = 1.6	7.0		18.5	8.3	9.1	
1903	Watertown N.Y.	Allen Hazen	Coag. basin and Reservoir. Intra. ellip., extra. parabolic.	2'-0"	1:2.9:5	10'-0"	1'-6"	6"	10"	18 x 18 = 2.25	0.68 = 1.7	6.9		9.9	8.3	9.1	
1903	Brookline Mass.	F. F. Forbes	Reservoir all concrete. Intra. ellip., extra. plane.	2'-0"	1:2:4	12'-0"	2'-6"	6"	none	20 x 20 = 2.77	none	10.1	0.40±	12.2	7.2	8.4	
1903	Philadelphia Pa. Belmont.	John W. Hill	Filters 18 of 0.74 acre. Intra. ellip. extra parabolic.	2'-0"	1:3:5	13'-5"	3'-0"	6"	2"	22 x 22 = 3.36	2.51 = 3.5	7.3		12.4	7.5	9.0	
1903	Philadelphia Pa. Belmont.	John W. Hill	Filtered Water Basin 382 x 394. Intra. ellip., extra. parabolic.	2'-0"	1:3:5	14'-0"	3'-0"	6"	21"	22 x 22 = 3.36	2.70 = 3.5	7.2		13.3	8.2	9.7	
1903 Begun	Philadelphia Pa. Torresdale	John W. Hill	Filters: 33 of 0.75 acre. Intra. ellip., extra. parabolic.	2'-0"	1:3:5	14'-0"	3'-0"	6"	21"	22 x 22 = 3.36	2.70 = 3.5	7.2		13.3	8.2	9.7	
1903 Begun	Philadelphia Pa. Torresdale	John W. Hill	Filters: 22 of 0.75 acre. Intra. ellip., extra. parabolic.	2'-0"	1:3:5	13'-2"	3'-0"	6"	21"	22 x 22 = 3.36	2.48 = 3.5	7.4		12.0	7.2	8.7	
1903 Begun	Philadelphia Pa. Torresdale	John W. Hill	Filt. Water Basin 602 x 762. Intra. ellip. extra parabolic.	2'-0"	1:3:5	14'-0"	3'-0"	6"	21"	22 x 22 = 3.36	2.70 = 3.5	7.2		13.3	8.2	9.7	
1903	Proposed for Washington D.C.	Col. A. M. Miller	Filters Nos. 1 to 24.	2'-0"	1:2.9:5	12'-2"	2'-6"	6"	17"	22 x 22 = 3.36	1.70 = 2.8	7.3		9.7 + sand stored	7.4	8.6	
1903	Proposed for Washington D.C.	Col. A. M. Miller	Filters Nos. 25 to 29	2'-0"	1:2.9:5	11'-10"	2'-6"	6"	17"	22 x 22 = 3.36	1.63 = 2.8	7.4		9.1 + sand stored	7.0	8.2	
1903	New Milford N.J.	Hering & Fuller	Clear Water well under Mech. Filters 2 sec. 47 x 148'	none		9'-8" 11'-8"	2'-6"	8"	none	24 x 24 = 4.0	none	11.7		30± ?	4.7 6.8	5.9 8.1	⅓ of clear well with these arches.
1903	New Milford N.J.	Hering & Fuller	do. do.	none		11'-8" 12'-6"	2'-6"	8"	none	24 x 24 = 4.0	none	12.3		30.± ?	6.8 7.2	8.1 8.4	⅓ of clear well with these arches.
1903	Proposed for Washington D.C.	Col. A. M. Miller	P.W. Reservoir	2'-0"	1:2.9:5	15'-6"	3'-6"	6"	24⅛"	30 x 30 = 6.25	4.0 = 1.5	7.9		8.7 + storage	8.6	10.3	

NOTE.—Later information shows the following corrections to dates: Albany, designed in 1897, built mostly in 1898, completed, 1899; Superior, completed, 1899; Watertown and three Washington items contracted for in 1903, but not yet built.

The sections of the vaulting over the outside and cross walls vary a little in different parts of the work. I have a large scale plotting of these sections as they were actually built, which I had made at the time, partly for the purpose of the final estimates and partly as a permanent record of exactly what was used.

For the amount of depression that we used at Albany, I still think the conical depression is better than the parabolic, but for the deeper cuts which have since been made it will not do, and I have thus used the parabolic curves on all my later designs.

Upon the Superior plant he says:

The depression over the piers at Superior is the same as at Albany and amounts, as I compute it, to 1.63 ins., instead of 1 in., with a corresponding reduction in the distributed thickness of the vaulting.

In regard to the Yonkers and Watertown, N. Y., plant, he writes:

The Watertown piers were made a little larger, relatively, than usual, because they were rather high and the Yonkers piers were considerably smaller than usual, being about normal for the 2-ft. cover. Putting the extra weight on the vaulting of course runs up the load per square foot a good deal. The increased thickness of covering in this case was an afterthought, which facilitated some other matters, and the size of the piers was not changed. At Yonkers the fill was made 4 ft., the extra depth being partly as a dike to protect against floods, and partly as a load to prevent possible floating with high ground water and with the reservoir empty.

While the smaller piers at Yonkers are undoubtedly amply safe, the saving in material does not amount to much, and next time I should make them uniform with the others. The curve of the roof is identical in the two designs, but there is a slight difference in the drop to correspond with the longer span at Watertown.

The above dimensions are the nominal dimensions. In actually laying the thing out I usually make the forms slightly shorter than the schedule, so as to give the contractor a little come and go. This facilitates the work greatly and the increased amount of concrete does not amount to much. When the piers are just right or are out in the wrong direction, of course this leaves a crack between the top of the pier and the center, which ought to be plugged before the concrete is placed.

In comment upon the Washington filters, Mr. Hazen writes:

While it is not intended to store sand on this vaulting it was intended to be strong enough so that the vaulting could be loaded pretty freely in this respect, and so that light tracks could be laid upon it.

Mr. Charles Hermany, Engineer of the Louisville (Ky.) Water Co.'s water purification station at Crescent Hill, Ky., gives the following interesting and exceedingly valuable detailed account of that work:

The year is given as 1898, because the design and dimensions were determined then and afterwards carried out without deviation. The work was completed in 1900.

Both the arches and columns are stronger than necessary, were they only to support themselves and the earth filling. This has been proven by building upon the groined arches a concrete bed 8 ins. thick over the crown, in which a track is built of standard steel rails, 80 lbs. to the yard, and loaded freight cars pushed over it with a combined dead and live load (car and freight) of five tons to the car-wheel without visible effect upon arch or columns. When designing these arches it was not apprehended that it would be desirable or necessary to run cars across them.

Great misgiving was manifested by contractors as to the practicability of building reliable columns of this description. The successful and satisfactory building of them proved to be one of the easiest and simplest tasks connected with the reservoir.

The concrete was machine-mixed, but all the manual labor was performed by crude and unskilled men, with which difficulty was experienced in satisfactorily building the arches; it was accomplished only by constant and vigilant engineering supervision. With the experience gained in this work, entirely satisfactory results could be obtained with reduction in both volume of concrete and cost of construction.

The solidifying of the concrete by tamping was done by hand, in layers of about 4 ins. in thickness at a time. Better results have since been accomplished by reducing the thickness of layers and using pneumatic tampers.

Memorandum of Feb. 8, 1902: The Clear Water Reservoir at the Louisville Water Co.'s Water Purification Station at Crescent Hill, Ky.

	Sq. ft.	Sq. ft.
(1) Total area of quadrangle space covered by the outside dimensions of the structure		180,740
(2) Area covered by the 4 retaining walls	18,541	
(3) " " " " " 3 division walls.	4,460	
(4) " " " " 256 columns supporting the groined arches	3,000	
(5) Aggregate area of water surface in the four compartments	154,739	
		180,740

Which water surface is the area roofed over by the groined arches. The groined arches are 340 in number, 270 of which are square, 22 × 22 ft. span between centers of columns, and 70 arches are in one direction of 22-ft. span, and at right angles thereto of variable span, both greater and smaller than 22 ft., owing to the quadrangular plan of the reservoir not being a square, but a trapezoid.

In the following table are given the items which comprise the cost of constructing the arched covering to the clear-water reservoir, subdivided into ten different classifications of material and work:

	Per sq. ft.
(1) 2,446.93 cu. yds. Portland cement 1:2:4 concrete in columns, at $7.10, $17,373.20 / 154,739 =	$0.11227
(2) 333.32 sq. yds. Portland cement, 1:2 mortar in columns, at 29 cts. $96.66 / 154,739 =	0.00062
(3) 7,484.11 cu. yds. Portland cement, 1:2:4 concrete in arches, at $7.10, $53,137.18 / 154,739 =	0.34340
(4) 978.13 cu. yds. Portland cement, 1:2 mortar in arches, at 42 cts., $410.81 / 154,739 =	0.00265
(5) 168,750 lbs. steel ribs in concrete arches, at 3¼ cts., $5,484.40 / 154,739 =	0.035444
(6) 7,325.89 sq. yds. neat Portland cement mortar, ½-in. thick plaster on columns, 23 cts., $1,684.95 / 154,739 =	0.01089
(7) 18,444.87 sq. yds. neat Portland cement mortar, ⅜-in. thick plaster on soffit of arches, 23 cts., $4,241.40 / 154,739 =	0.02741
(8) 3,928.04 cu. yds. earth fill over arches, 30 cts., $1,178.41 / 154,739 =	0.00762
(9) 154,739 sq. ft. sodding, at 10½ cts. per sq. yd., $1,805.29 / 154,739 =	0.01167
(10) Centers for arches and falseworks, $9,000.00 / 154,739 =	0.05863
	$0.61060
Less Correction	0.00046
Total cost per sq. ft. of covering	$0.61014

In the above items (2) and (4) are for mortar used to interpose between successive additions of concrete, so as to make such additions adhere to each other.

The foregoing ten items of cost comprise the total amount paid by the water company to the contractor, to which wants to be added the cost of inspection and engineering supervision, which amount is not exactly known, but will approximate closely to 10% of the cost.

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The Butler typhoid epidemic, reported on at length in this issue by Dr. Geo. A. Soper, who spent nearly a week in Butler for this journal, would never have occurred had the local water company and the local board of health exercised the ordinary and well known precautions which should always be adopted in municipal sanitation. But even with the omission of all such precautions a proper system of reporting cases of disease would have given warning of the impending danger at an early stage. Efficient health board measures to check the outbreak at its start, and particularly to prevent secondary infection, might have kept the number of cases and deaths down to a comparatively small number.

Judging from all the evidence in hand, Butler might almost as well have had no local board of health as the one which accepted the grave responsibilities of that position. In fact, perhaps it would have been better off without than with the existing board, upon which more or less reliance was placed until it showed its utter incapacity. The deficient official records of typhoid cases at Butler are alone sufficient to condemn the local board of health, and with it the local physicians and the whole State of Pennsylvania, which latter must be held largely responsible both for the lack of vital statistics in one of its municipalities, and for such inefficient sanitary measures as were exhibited at Butler by both the local government and the water company. The Butler epidemic seems all the more inexcusable in a State which might have been expected to profit from the Plymouth epidemic of 1885. We point out these things without forgetting that the chief responsibility for the epidemic must be laid at the door of the Butler Water Co. It was its business to know whether the water was polluted, to exhaust its powers to stop the pollution, and, if those powers failed, to guard the public in every possible way against the dangers that might ensue, and even if necessary to notify every consumer of his danger.

Finally, we wish to repeat our warning of a week ago, that hundreds of communities in this country are liable any day to be overwhelmed with the horrors of such an epidemic as that at Plymouth, or Ithaca, or Butler. These communities merely had to pay the penalties for impure water and lax sanitary administration which other communities, equally neglectful, have been fortunate enough to escape.

About two years ago, at the time of the collision in the Park Ave. tunnel, a great cry went up against the steam locomotive and a universal public demand was voiced by the newspapers that electricity should be substituted for steam in the Park Ave. tunnel. We pointed out at that time that while electricity would eliminate certain dangers, it would introduce others that might prove even more serious, and that the question of motive power ought, therefore, to be considered on its merits by competent engineers and not left to the prejudice of the moment.

At the present time the press of New York City is well nigh as much exercised concerning the dangers of electricity as it was two years ago over the dangers of operating the Park Ave. tunnel with steam locomotives. The holocausts on the Paris Underground Ry. and in the Liverpool tunnel, combined with the very numerous cases of fire set by electric current on surface and elevated cars, and men killed by contact with the third rail, have taught the public that electric traction certainly does introduce dangers from which the steam locomotive is free.

Just at present public attention is concentrated upon the third-rail dangers on the elevated railways of Greater New York. The Fire Department has raised a formal protest against the third rail on the ground that the firemen have frequently to work on the elevated structure to fight fires, and they are subjected to great danger from contact with the heavily charged rail. In numerous cases also when trains have been stalled between stations, passengers have been subjected to great risk in passing along the structure to reach a station.

To this indictment the elevated railway managers reply that the third-rail system represents the latest and best practice in electric traction, and, in fact, the only system in actual use capable of transmitting the very heavy currents that they require. As for protecting the third rail, while that has been done to some extent on some surface roads of light traffic, no system has yet been worked out adapted to the conditions met with on the elevated lines.

Of course the proposal comes from numerous quarters to isolate the third rail into short sections and then by automatic switches to cut off current from all the sections except those occupied by trains. This would be a very nice plan if the quantity of current to be dealt with were something like that used in telegraphy; but switching on and off currents heavy enough to propel elevated trains is a totally different matter. It is something like the difference between closing a water faucet over a wash basin, and closing a gate in a 30-in. water main.

A curious suggestion has been made by no less a person than Mr. Geo. Westinghouse. It is that the third-rail system is after all a mistake and that the best place for the line conductor is overhead like a trolley wire. Mr. Westinghouse brings forward some very plausible arguments in support of his idea; but he fails to mention the fact that the firemen would doubtless object to such an overhead conductor even more strenuously than they now do to the live third rail. There are besides a good many practical difficulties in the erection and maintenance of an overhead conductor large enough to meet the requirements of heavy railway service. The Baltimore & Ohio R. R. originally erected and used for some time an overhead conductor for its electric locomotives on the approaches to the Baltimore tunnel; but it afterward replaced it with a third-rail system.

Probably the best that can be done to improve the situation on the elevated railways will be to provide switches at the stations by which, in case of fire or accident, the current can be cut off from the sections between stations, by the station attendants, who are always on duty when the road is in operation. This plan will have the merit of simplicity and reliability in operation, which is a matter of exceedingly great importance in the case of the New York elevated railways. The adoption here of any complicated automatic current switching system, containing even remote possibilities of getting out of order and shutting down the traffic, is wholly out of the question.

We call attention to these features of danger, not by any means because we oppose the use of electricity, but because we would have it considered on its merits. Its adoption in a particular case may be justified for commercial reasons or because of the nuisance caused by steam locomotives to residents along the line of the road, or because of grades to be surmounted, or for any other sound and sane reason. To urge its adoption on the ground of safety, however, as was done so vehemently two years ago, cannot be justified by any unprejudiced person. In fact, the record of recent months goes far to show that experience with electric railways will have to be much more extensive before they can attain a safety in operation at all comparable with that attained in the regular operation of steam railways.

The final report of the Commission on Additional Water Supply for New York City, an abstract of which appears elsewhere in this issue, cannot but be regarded with approval by engineers and sanitarians generally. Criticisms of details may be expected as a matter of course, when the details are made public, but the main features of the report will doubtless be received with universal approbation. Broadly speaking, the commission proposes a high pressure supply of 500,000,000 gallons daily of filtered upland water, part to be developed as speedily as possible and the whole within 25 years, as the growth of the city demands. It also proposes to filter the whole of the Croton supply at the earliest possible date; to develop to their fullest practicable extent the underground waters of Long Island available for Brooklyn and Queens Boroughs, and to filter all surface supplies delivered in those boroughs. In other words, the great city of New York would ultimately be provided with a most bounteous water supply, every drop of which would be filtered by either natural or artificial methods. This is in accord with the Imperial German regulations governing public water supplies, and with the best engineering opinion in Great Britain and some other European countries. It is also in harmony with the ideas of many, perhaps most, American engineers. In fact, probably there are few engineers in this country or elsewhere who would not recommend filtration of all surface water supplies if they felt that the public would back them up with the necessary appropriations.

In the matter of waste prevention perhaps the commission has gone quite as far as public sentiment will warrant, and it is certainly on the side of safety to regard waste prevention as affording merely a greater margin between the supply and demand of the future, rather than as a means of delaying the introduction of large additional quantities of water. The recommendations of the commission to the effect that both the house to house inspection and the installation of meters be continued may, if followed, materially lessen the successive additions to the supply needed in the future, and even if they do not materially reduce or postpone construction expenses for the main works they may have a salutary effect upon the cost of installing and operating filters.

That careful attention needs to be given to waste prevention and every other practicable means of keeping down water consumption must be evident to any one who takes a broad view of the municipal needs of New York City during the next 22 years. The commission has recommended the completion of vast new works by the year 1925 which will cost practically $100,000,000, but that sum does not include the cost of the additional underground water supply on Long Island, of filtering the existing Croton supply or the surface

supplies on Long Island. Other items of expense not included are the cost of connecting the new gravity supply with Brooklyn and Queens Boroughs, and of supplementing the supply of Richmond Borough or Staten Island. Nor does the $100,000,000 include a cent for what the commission calls "water right damages."

New York is a great and wealthy city, and it will be far greater and more wealthy in 1925, but any such huge expenditure as is under discussion should be considered in the light of other municipal needs, many of which, though hardly as vital as water supply, are of great sanitary importance. Assuming the water-works to be entirely self-supporting, or even a producer of net revenues, their finances inevitably have much influence on the finances of the city as a whole, while if any money can be saved by cutting down waste the opportunity should not be lost. The commission is therefore to be commended for all that it has done and said in the interest of waste prevention, and when the problem of an improved supply is considered by the city authorities and the public in its broader aspects, and in relation to other municipal problems, the commission's recommendations for more meters and waste inspection should be accepted and acted upon in their broadest possible sense.

A curious illustration of the tenacity with which the old-time weights and measures continue in use in Great Britain comes to our notice in an advertisement of the Great Western Railway. We quote from it as follows:

> The directors of this company are prepared to receive tenders for the construction of new railway lines at Bristol Harbor, the total length being about 6 furlongs.

We wonder what proportion of American engineers, particularly of the younger generation, could tell offhand the length of a furlong. Certainly they would no more think of using the term in a contract than they would the biblical cubit.

From ridicule to respect has been the changing attitude of the public on the recent proposals to exterminate mosquitos. Such tangible results have now been achieved and the hearty co-operation of such a large number of property owners, entomologists, engineers, sanitarians and public-spirited citizens generally has been secured as to make possible a well-attended conference of representative men, at which papers on various aspects of the mosquito problem were read and steps taken to form a permanent national organization to combat the mosquito nuisance and menace. The conference was held in New York city on Dec. 16, and a report of its proceedings will be found elsewhere in this issue. As a conference, the gathering was notable for its many brief and forceful addresses, and the character of the men who presented them. As a discussion of a vital economic and sanitary questions, affecting the comfort, prosperity and health of millions of people, the remarks were of a distinctly practical, rather than theoretical character. Prominent New York men of affairs told of the satisfaction they had derived from money and time expended in exterminating mosquitos on their Long Island, Staten Island and New Jersey estates. Engineers and entomologists told of their part in the study of the problem and in its successful solution. No one questioned the possibility and feasibility of reclaiming any mosquito-infected section and of suppressing both malaria and yellow fever, if individuals and municipalities would co-operate, and, in the case of large areas, if State and perhaps National governments would join in the work. Except for preliminary studies, however, local action alone will generally be sufficient. Once the biological side of the question has been determined, funds raised, and private and public co-operation secured, the work of mosquito extermination generally resolves itself into the engineering problems of drainage, filling, and, in some cases, the construction of dams or tide gates to control water levels. "Mosquito engineering," as Mr. Henry Clay Weeks, one of the most prominent workers in this new departure,terms it, promises to afford many opportunities to engineers in the future. Quite aside from the advantages of mosquito extermination, great as they may be, are the possible commercial profits due to the reclamation of vast areas of rich swamp and marsh lands now serving as breeding grounds for mosquitos. It will be for the interests of engineers, as well as municipalities and the general public, to further the good work of mosquito extermination in every possible way.

THE EDISON CEMENT WORKS.

Practice in cement mill equipment and machinery has for some years past adhered quite closely to well-established standards. Examination of the plans of a number of recent cement mills selected at random will disclose differences in the arrangement of the buildings and in their coordination, but so alike are they in machinery equipment that the crushers, kilns and grinding machines of one might almost be substituted in another without noticeable change in the working of the plant. In view of these facts the departure from prevailing practice, which has been made in constructing the mills of the Edison Portland Cement Co., at New Village, N. J., has brought that plant somewhat prominently into notice and considerable curiosity has been shown in the exact nature of the machines and methods by which the famous inventor expects to improve on the work of his predecessors in the manufacture of Portland cement. As the Edison cement works have now been completed and in operation for several months a description of their construction and equipment is possible, and is given in another part of this issue.

It is deserving of comment that after an unusually exhaustive survey of the available deposits of raw materials the old and well-known Lehigh Valley District was selected as the best location for the new works. The argillaceous limestone rocks of this district, which embraces a large section of eastern Pennsylvania and western New Jersey, are an almost ideal rock material for cement manufacture. They are of a soft shaly nature, easily blasted, easily sledged, easily handled by steam shovel and easily crushed and ground. The only drawback of the district is that the high carbonate rock necessary to bring the cement rock up to a normal composition for cement making is seldom found close to the cement rock deposits. Many mills in this district must haul their carbonate rock from separate quarries, often a considerable distance away. The cost of this transportation is considerable and brings the cost of the limestone ingredient, according to a recent estimate by Mr. F. H. Lewis, M. Am. Soc. C. E., up to from 85 cents to $1.25 per ton as compared with a cost of from 18 to 30 cents per ton for quarrying the cement rock. In view of these facts the apparent advantage which the Edison works have in their deposits of limestone and of cement rock in practically the same quarry is obvious. This advantage is probably offset to some extent, however, by somewhat greater quarry irregularities in the composition of both rocks which means of course greater expense in maintaining a uniform mixture at the mills.

It is not, however, in the quarry but in the mills that the Edison works present the greatest differences from the prevailing practice of the Lehigh District. In examining the plan of the works the most striking features which present themselves at first glance are the widely scattered arrangement of the buildings and the employment very generally of a separate building for each process. The tendency in most of the more recent cement plant designs has been toward concentration; the buildings have not only been brought close together, but they have been reduced to the minimum number by conducting a group of co-ordinate operations under one roof. A notable example of this practice is furnished by the works of the Hudson Cement Co., described in Engineering News of July 23, 1903. Few Portland cement works are so compact in arrangement as these, and this is particularly true of the older works of the Lehigh District, which have grown by the gradual accretion of new buildings added as the occasion demanded and whenever the space could be afforded. In no works of recent construction, however, has the segregation of buildings and processes been so pronounced as in the works illustrated here. It is worth a moment's study to ascertain the reason for this fact.

It will be understood, of course, that the strung out appearance of the works is due in some degree to the fact that they were laid out for the full capacity of 10,000 barrels per day and space was left between the various buildings to accommodate the increase up to that capacity. At present, as will be observed from the plan, only the stone crushing and storage buildings and machinery have been constructed to the full projected capacity of the works.

The provision of separate buildings for such process was determined by three considerations mainly. It permitted the division of the plant into sections entirely independent of each other. As laid out, the works are divided into five sections with storage between and with independent power for each. In case of a breakdown in one section the other four can continue to operate. A still more important advantage is that one section of the plant can without stopping the other mills be shut down for overhauling when the occasions demands. Secondly, by providing separate buildings all heavy machinery requiring larger foundations could be kept close to the ground, thus economizing in the cost of foundation work. Finally by having all heavy machinery founded on the ground it was possible to erect very light steel buildings. This again cheapened the cost of construction.

The selection of a level site for the works instead of a side hill site which was readily available had it been preferred can be looked at from two points of view. In the present case it was found cheaper to secure artificial elevations by constructing piers than to make the excavations required for a side hill plant. On the other hand extensive provision had to be made for conveying the material frequently from a lower to a higher level in its course through the works. The arrangement of the buildings permitted this work to be done very largely by belt conveyors, and many of these, as will be observed from the plan given elsewhere, were of unusual size. With one unimportant exception the conveyor belts have an angle of 16° from the horizontal, which is well below the possible angle at which they can be worked successfully. Their size is unusual and judging by practice in cement mills generally may turn out to be a doubtful economy. The relative advantages of wide and narrow belts is, however, a complicated question and cannot be decided off-hand. In this connection, therefore, we shall note merely that where most mills employ 14-in. and 16-in. belts, the Edison works have 24-in. and 36-in. belts.

Before passing from the conveyor system of the Edison plant one or two minor features deserve mention. It is worthy of note that none of the belts are troughed, but travel on horizontal carriers and have flanges at the edges to prevent spilling. Another device which is of interest is the traveling screw conveyor employed, one in the raw material stock house and the other in the cement stock house. This is an ingenious device for taking fine material from piles, and seems to possess distinct advantages over the method of chuting the material onto conveyors in tunnel.

In reducing both the rock and the clinker the usual principle of gradual reduction is followed. The rough crushing is done entirely with roll crushers. This is novel practice to the extent that heretofore roll crushers have been employed only for a late stage of the rock reduction, the preliminary breaking of the quarry product being done by gyratory crushers. The real novelty of the method of rock and clinker reduction in the Edison works consists, therefore, in the use of rolls for fine grading and the employment of wind separation both before and after the grinding. Stated more clearly, both the crushed clinker and the crushed rock are put through the blowers to remove the fine material before they are fed into the grinding rolls for the final stage of reduction. Separation between stages is not entirely new, but no extensive practice of the kind has yet been developed and for this reason the practice of the Edison plant is notable. It is also deserving of notice that in reducing the clinker ample provision is made for the crushed clinker to season and soften in storage before it is passed to the final grinding.

In regard to the actual efficiency, economy and durability of the roll grinders but little information is available. The standard for fineness in grinding, namely 90 per cent. through a 200 seive, is very high. It is worthy of notice also that this standard applies to the grinding of raw material as well as to the grinding of clinker. The real test of roll grinding of course is not the fact that such fine reduction is possible, but the fact that it can be accomplished at less cost than by other grinding machines. On this point we have no figures. It has always to be borne in mind that fine grinding is simply a commercial proposition; a cement 90 per cent. of which will pass a seive of 40,000 meshes per square inch can be produced by any of the standard grinding mills, but it will cost more to manufacture than a coarser cement.

In kiln practice the Edison works differs from that of other plants making cement from dry raw materials in the extraordinary size of the kilns used. These are 150 ft. long and 10 ft. in diameter and are of the taper type with the diameter reduced toward the chimney end. The kilns ordinarily used for burning dry material are 60 ft. long and 6 ft. in diameter. The enormous difference in dimensions is readily seen; roughly, each unit of the kiln house is twice as large as the usual practice demands. This means of course much greater first cost and greater expenses for power and maintenance. To justify these there must be a material increase in output. The ordinary 60 ft. kiln yields from 7 to 10 barrels of clinker per hour with a consumption of from 80 lbs. to 140 lbs. of coal per barrel. Exact figures of output and of coal consumption for the large kilns at the Edison works are not available, but we are informed by the managers that the average monthly output of each kiln is over 30 barrels per hour with a coal consumption of less than 80 lbs. per barrel of cement. These are remarkable figures and on their face would seem to demonstrate the wisdom of the greater units employed by the Edison works. It is too early in the day, however, for the last word to be said in this matter.

In respect to the minor machine equipment of the Edison works we have said almost nothing, but it is in many respects deserving of mention. Except for the crushing and grinding machinery the plant is operated by electric motors taking current from a central power house. Beyond this general statement we have space to mention here only one feature which offers a hint of value to managers of electrically driven shops. This is the protection of the motors by enclosing them in a gunny-cloth box or casing. This is a neat and simple device which will prove of service in many other places. Where electric motors are used as a source of power it is often necessary or desirable to enclose them, either to protect the machine from dust or to render harmless any sparking that may occur. A rather common plan is to use motors in which the frame forms a closed shell, the so-called enclosed type of motor. But when so built a motor is always restricted to a lower capacity limit than when the shell is open to permit free access of air to the armature, and to get the same power a larger and more expensive motor must be used. It will be cheaper in many cases, and equally effective, to build an enclosure around the motors of the style used at the Edison plant. The thin porous gunny-cloth will keep out the dust and yet permit adequate cooling action.

LETTERS TO THE EDITOR.

Stone and Slag Ballast.

Sir: In the article on "Stone Ballast," by Mr. Hermann, in Engineering News of Dec. 17, it is stated that while slag has many of the advantages of stone, "its use is necessarily confined to the immediate vicinity of the locality of its production, an area so small that it may almost be considered a negligible quantity."

In view of the number and distribution of blast furnace plants it would seem that the use of slag is much more generally available than the above quotation implies. In Tratmann's "Railway Track and Track Work," after describing the use of slag ballast, there is the following suggestion:

> In view of its low cost and its excellence as ballast, it might well be adopted by many roads now using inferior and dusty gravel on their main tracks. Where the traffic is heavy, the improved condition of track and the reduced cost of maintenance would probably warrant the expense for transportation of slag ballast from the furnaces.

Yours truly, "Ballast."

Chicago, Ill., Dec. 17, 1903.

Designs for Hollow Concrete-Steel Dams.

Sir: In January, 1903, the writer designed a hollow concrete-steel dam, in connection with the development of a water power in Standish, Me., the cross-section of which is essentially the same as that illustrated and described in Engineering News of Nov. 5, 1903.

In designing the floor of this dam the slope was divided into four nearly equal horizontal sections. The maximum load for each section was calculated and a concrete-steel slab designed for that load.

The slab (considered as a whole) was uniformly tapered from 11 ins. in thickness at the bottom to 4 ins. at the top, and reinforced with sufficient steel, varying in size, to furnish a resistance in each section as nearly as possible proportional to the load for that section. The carrying rods were spaced 4 ins. c. to c., and the distributing rods 12 ins. (See Fig. 1.)

The piers, which were designed to be of boulder concrete, were spaced 12 ft. c. to c., and were 2.5 ft. in thickness. It will be seen that a reinforced concrete beam is introduced at the crest of the dam to provide additional strength at this point, in order to resist the shock due to the passage of floating material over the dam.

The probable cost of this form of dam is somewhat less than 80% of that for a solid gravity dam with the same factor of safety.

A form of construction somewhat more economical in the use of cement and steel is shown by Fig. 2, in which concrete-steel beams of uniform cross-section but unequal spacing are introduced in connection with a thin concrete-steel floor in place of the single slab, as in the former design. This form of construction while more in keeping with the practice for ordinary floor design is probably not much more economical, in this instance, than the first, as the increased cost of the forms would nearly balance the saving in cement and steel.

Yours truly, H. W. Foster,

Constructing Engineer, Eel Weir Falls Power Plant.

Standish, Me., Nov. 21, 1903.

Experience With Wrought-Iron and Steel Pipe in Well Sinking.

Sir: In reply to your inquiry in regard to wrought-iron pipe, vs. steel pipe, for use in test borings, and general well-sinking work, I would say after about 15 years' practical experience in the above work, in all of its branches, I can say nothing in favor of merchant steel pipe. It is hard and brittle, weak in the weld, difficult to thread with ordinary methods, usually breaks when driven in ordinary ground. It can seldom be drawn when driven to any considerable depths without breaking, thereby leaving a large amount of new pipe in the ground, where it is desirable to withdraw and redrive. On the other hand good quality wrought iron pipe is tough and can be perfectly threaded with ordinary methods. It will stand any reasonable amount of hard driving and can be withdrawn and redriven until it is worn out. When properly taken care of and newly threaded when necessary, it is very seldom that a piece is lost by breakage.

A few years since I undertook to sink a 10-in. diameter wrought-iron pipe to a depth of 100 ft. in Post Office Square, Boston, Mass., for the Boston Water Department. There was no wrought-iron pipe to be had of the desired size at that time. The dealer (one of the most reliable in Boston) made special effort to get the very best quality of steel pipe made, which was accepted by the commissioner and myself. The pipe was very carefully driven, was perfectly straight and a hole drilled below it at all times when it was driven, the hole being the full size of the internal diameter of the pipe. There were no unusual obstructions encountered and the driving was not unusually hard. We were obliged to stop at a depth of about 96 ft., as the threads on the pipe were so badly used up that it would stand no more driving.

I have used good quality wrought-iron pipe in sizes from 2 ins. to 12 ins. in diameter in much harder and more difficult places and had very little trouble from breakage. Whenever I have been obliged to use steel pipe I have always had some trouble on account of breakage, and it would seem that the work done under this commission, during the past season, is good evidence that the manufacture of steel pipe has not been improved to date. Yours very truly. Edward A. Clark.

Superintendent of Test Borings for Commission on Additional Water Supply for New York City.

Brown's Station, N. Y., Dec. 8, 1903.

(Previous letters on the above subject were printed in our issues of Oct. 1, Oct. 8 and Dec. 3. Mr. Clark's letter above was written in response to a request by Mr. John R. Freeman for further information upon the subject.—Ed.)

Fire Resisting Curtain Walls of Sackett Plaster Board.

Sir: Noticing in your issue of Sept. 10, 1903, an account of curtain walls of expanded metal and plaster, suggested to the writer that a mention of the use of Sackett plaster board for a similar purpose would be of interest. In the year 1901, and since, certain trusses of three large new buildings have, at the suggestion of the writer, been covered with this material. One of these is a one-story frame building 80 ft. wide and 769 ft. long, with three lines of covered trusses; another is a two-story frame building 222 ft. wide and 255 ft. long, with two lines of the first floor trusses covered, the area of the upper floor being cut up by partitions, one of which was sheathed with the plaster board. The third building has brick walls and is 155 ft. wide and 280 ft. long, with two lines of covered trusses. The "plaster board" referred to is of fire-resisting material manufactured in sheets 32 × 36 ins., and of three or more different thicknesses. In the cases mentioned above, the plaster board was nailed to spruce framing, cut in between the members of the trusses, as well as to the members themselves and to the brackets and posts at the side walls. Where monitors occurred the furring and plaster board work was extended on their frames, to the monitor roof. Two thicknesses, each ¼-in. thick, laid so as to break joints and on both sides of the trusses makes the most thorough work. The material can be easily sawed and so can be easily made, by the carpenters, to fit irregularities. The cost in Boston of the ¼-in. thick material is from 16 to 18 cts. per sq. yd., according to the quantity purchased.

The work was carried to the underside of the roof or floor planks only, which were, in all cases, at least 1¾ ins. thick; the idea being that if a fire is prevented from

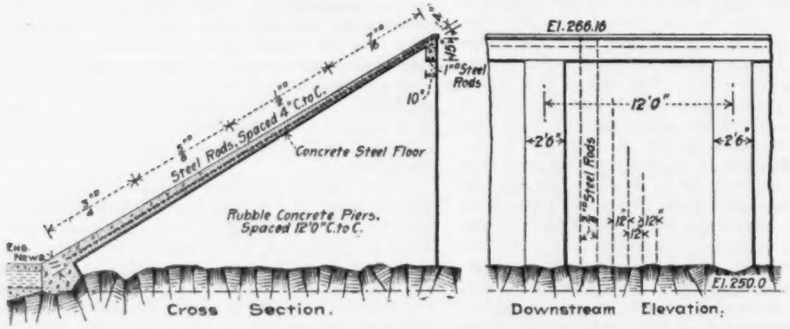


Fig. 1. Proposed Design for a Hollow Concrete-Steel Dam.

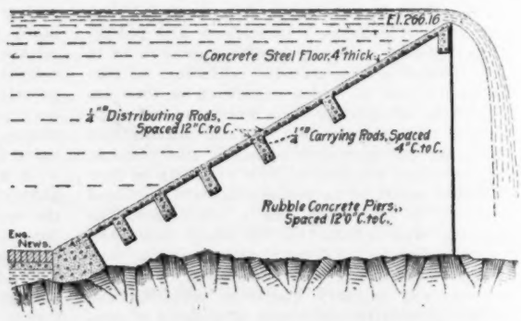

El. 266.16
Concrete Steel Floor, 4" thick
¼" Distributing Rods, Spaced 12" C. to C.
1" Carrying Rods, Spaced 4" C. to C.
Rubble Concrete Piers, Spaced 12'0" C. to C.
Eng. News.

Fig. 2. Alternative Design for a Hollow Concrete-Steel Dam.

spreading over a period long enough to burn through a 1¼-in. plank it is about all that can be expected of a fire stop of this nature.

From observations, by the writer, of the effect of several fires in long wooden buildings he is convinced that had some such simple expedient as the one above mentioned been used the damage by fire and water would have been very much reduced.

It is needless to say, that, in the three cases mentioned by the writer, the use of brick or any other complete fire

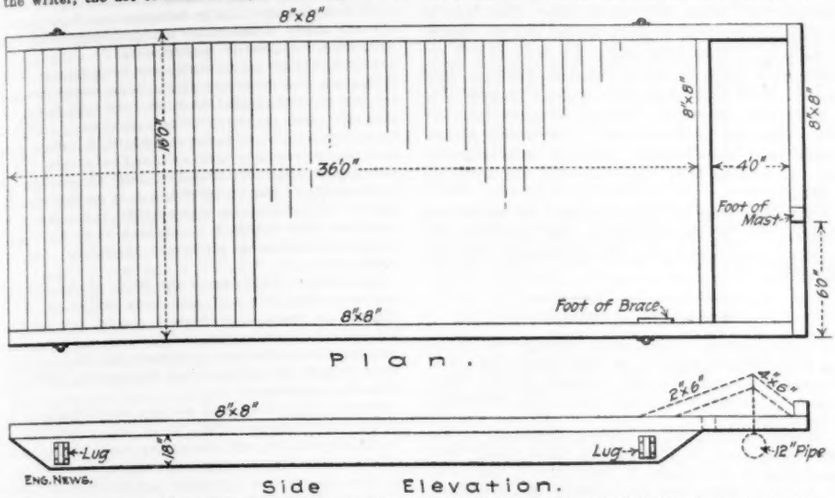


FIG. 1. PLAN AND SIDE ELEVATION OF WALKING SCOW FOR SUBMARINE PIPE-LAYING.

walls would have been out of the question on account of the character of the business being carried on in the building.

For a description of fire tests of Sackett plaster board, with other materials, see "Report of Tests of Fire Retardent Materials," made by Chas. L. Norton, for the Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

Yours truly, William Parker,
Division Engineer, Boston & Albany R. R.

Boston, Mass., Dec. 14, 1903.

A "Walking Boat" for Subaqueous Pipe Laying.

Sir: Thinking that some of the readers of your valued paper may wish to lay pipe across a river having a rapid current, I send you herewith a sketch of a "walking boat" that I have designed for that purpose. I have found it next to impossible to work in a rapid current when using anchor lines, so I devised a method of dispensing with all anchor lines, using spuds instead, as I shall now describe.

Fig. 1 shows a 16 x 36-ft. scow provided with four lugs through which the spuds can be dropped. The spuds are 2½-in. pipes, 14 ft. or more long. Only two spuds are used in working the boat out from the shore. Start at

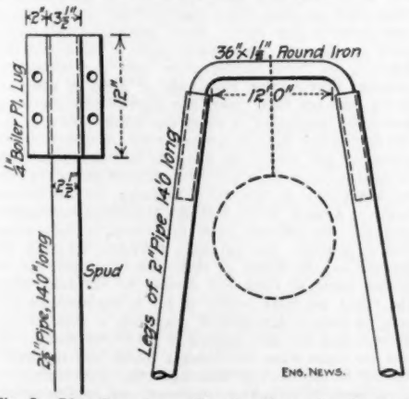


Fig. 2. Pipe Speed and Lug.

Fig. 4. Horse for Supporting Pipe.

least 100 ft. above the line of the work and drop down with the current to the line of the work, then place all four of the spuds to steady the boat. Referring to Fig. 3, assume that the boat is in the position shown by the full lines, and it is desired to begin moving across the stream; remove the two starboard spuds, leaving spuds 1 and 2 on the larboard side. Next raise downstream spud 2, and swing the boat about spud 1 as an axle till it takes the position shown by the dotted lines, and drop the downstream spud at position 3. Now raise upstream spud 1 and swing boat about spud 3 as an axle, dropping upstream spud again in position 4. In this manner I have moved the scow 125 to 130 ft. in 12 moves. Two boat chain blocks. The boat is "walked" ashore from time to time to get a new load of pipe, the iron horses supporting the pipe while the boat is gone. I have carried 12 to 14 lengths of 12-in. pipe, and the same of 20-in. pipe, before using a ball joint in 8 ft. of water; but in 10 or 12 ft. of water I use a ball joint every 96 ft., or 8 lengths.

By taking a card to represent the boat and using two pins for spuds, it will be seen that the boat can be walked up stream, or down stream, or directly across, accordingly as the spuds are placed.

In a swift current I have found no method as satisfactory as the one above described for laying submerged pipe.

Yours truly,
John De Galleford, M. E., General Contractor.

Chattanooga, Tenn., Dec. 3, 1903.

Methods of Mixing Concrete.

Sir: In your issue of Dec. 10 Mr. Ernest McCullough gives some specifications for mixing concrete. There seems to be considerable diversity of opinion among engineers regarding this subject, and excellent results may be obtained in several different ways, the one essential point being the thorough intermixture of the ingredients.

After a long experience in concrete mixing, I have finally adopted this method as the best: First, spread the sand, then upon the sand spread the cement and mix the two thoroughly, dry. Then thoroughly drench the stones and spread them on the prepared dry mortar. Finally turn the mass over and over, adding water gradually until the desired degree of moisture is attained. I consider it of great importance that the sand and cement should be well mixed dry, separately, and have even insisted upon this when the concrete was mixed in a machine. Also, that the stones should be wet separately before adding or when added. The use of bottomless boxes as suggested by Mr. McCullough is good. Generally, or at least very often, cement barrels are used to measure the sand and stone. This method has the advantage of using the same measuring vessel for all the ingredients, and also that one or two men can be constantly at work filling barrels with sand and stones, and standing them, handy by, for use as wanted. This makes the work go quicker. As the cement is shaken down in the barrels it is only fair to the contractor that the sand and stone barrels should be filled heaping. When cement is furnished in bags, four bags are commonly considered as equal to one barrel, and the bottomless box then comes into play, with the open question: How many cubic feet to the barrel? Usually, 3⅓ cu. ft. will not be far out.

E. Sherman Gould.

Yonkers, N. Y., Dec. 11, 1903.

Sir: Noting the letter in your issue of Dec. 10 from Mr. Ernest McCullough, in the matter of mixing concrete, which I read with interest, I beg leave to say that after 25 years' experience in handling concrete I have come to the conclusion that the strict order of adding the materials has not the importance commonly attached to it. The manner in which the work is done is the principal thing, of course taking for granted that the cement is of required quality and proportion of aggregates correct. Most engineers and architects have a specification of their own and if almost any of them is followed faithfully, good concrete will result.

Personally, I favor making the mortar first and having the stone (ready measured and handy in barrows, after being wetted) dumped into the mortar as evenly as may be practicable and rapidly turned over, say, twice before reloading into barrows and depositing in place. Mr. McCullough himself names the objections to so much turning over, and twice, with the necessary handling of putting into barrows and dumping into trench, is mostly sufficient. I am in favor of making the concrete wetter than is usually considered "wet enough," having many times practically demonstrated that a better result is obtained by giving the cement more time to reach its initial set and the mass more readily becoming homogeneous.

I have observed that by mixing all the parts dry first, and then applying water, that the cement is work to the bottom of the heap and often cakes there, and even if turned up again it has a tendency to adhere to the sand and avoid the stone. At the same time if care and skill are used in the manipulation good concrete can be obtained this way as well as any other.

The principal cause of failure is the fact that making concrete has been looked upon as simply so much labor, whereas much skill, only to be acquired by experience, is necessary to secure the best results, this both in the mixing, the dumping and the tamping.

Yours respectfully, Henry G. Hammon.

Cape Vincent, N. Y., Dec. 14, 1903.

Central Power Station for New England Water Powers; Efficiency of Low-Head Wheels in Series.

Sir: In your issue of Nov. 26 you publish my comments upon Mr. Perrine's paper (issue of Nov. 5), together with a rejoinder by him to those comments. He says:

> In addition to the loss which Mr. Swain mentions there is always, in case of wheels in series, a very considerable proportion of the head which is not available, but which could be made available by the use of a single wheel. This is on account of the necessity for a certain velocity of flow in the tail race in order to clear the dead water away from the wheel and a certain unavoidable velocity of flow in the head race.

Now, while this is quite true, if we except the misnomer "dead water," which we will discuss later, it is not necessarily so except to a very limited degree. The best modern turbine installations of to-day are never without properly constructed draft educts to convey the water discharged by the turbine to the tail race with the least possible loss of head consistent with its commercial value, as well as to have the water come to the turbine in properly proportioned penstocks. The modern turbine, however, is not always provided with proper draft educts, which are fully as important as the correct thing in penstocks, whereas the losses are often much greater in leaving the wheel than in coming to it.

An instance of the bad design of educts was seen last August, in Franklin, N. H., where an apparently fine dam had just been completed across the Pemigewasset River, forming a reservoir several miles long, by means of which a great water power is being developed. Massive abutments of granite had been built up at each end, provided with headgates and chambers with large pen-

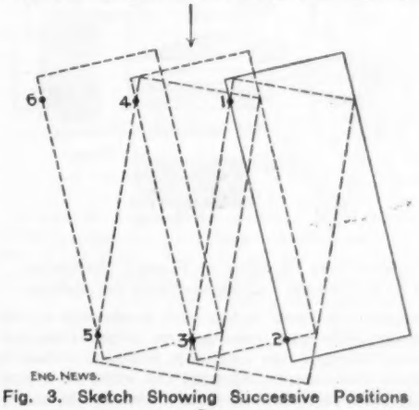


Fig. 3. Sketch Showing Successive Positions of Scow.

stocks for conveying water to the turbines to be installed. Two small ones had already been placed, with draft educts leading from them to the tail race at an angle of about 45°, made in the old-fashioned way, of the same diameter at top and bottom, the sheets alternately inside and outside for 20 ft., more or less—and this in a large manufacturing town where steam power must cost $30 to $40 per HP. per year, and on a stream that gets very low in a dry season. The truth is, not one manufacturer in a thousand knows there is any advantage in the modern diverging draft educt over the old styled one described above. Nor are their mechanical or hydraulic advisers much better informed.

If we had "dead water" or "inert water" at the moment

of leaving the buckets of the wheel it would little matter what the style of the draft educt was, if it were of ample area to dispose of the discharged water without back pressure. It is quite impossible that there should be any "dead water" near the discharge edge of the turbine buckets, with the gate open, under any appreciable head of water. We know that if 100 cu. ft. of water are made to pass through an opening of 100 sq. ft. in one second of time, the average velocity must be 1 ft. per second, and if the area is reduced to 10 sq. ft. the average velocity must be 10 ft. per second to pass the same quantity of water in the same time. Applying these simple principles to the modern turbine, we find that instead of "dead water" we have a living moving force; a "living force" (vis viva) moving with a velocity of 8, 10, 12, 15, and, sometimes, 20 ft. and more per second. This means 5, 10, 15 or 20% dead loss, according to the head of water under which the turbine is acting wherever the Franklin style of draft educt is in use. With a properly constructed educt it becomes possible and feasible to make two-thirds or more of this "living force" available in additional useful effect of the turbines.

Since the foregoing was written it has been learned that a boilermaker of this city has an order for five straight draft educts from a prominent firm of turbine builders, who send them south and who know, by actual test, that they can gain 3 HP. or more on every hundred by the adoption of improved educts.

The time is coming when the demand for such improved draft educts will be almost universal and the straight kind tabooed by all intelligent mill men. Occasionally, even now, one meets a prospective buyer who stipulates for such improved educts and will have no other.

Very truly yours, Asa M. Swain.

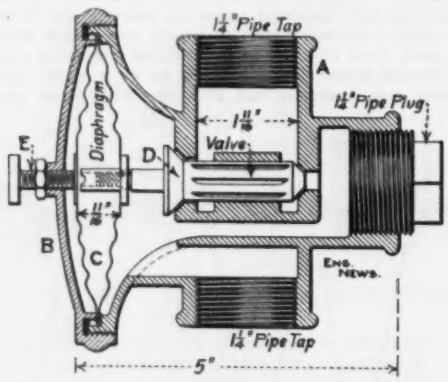
223 School St., Lowell, Mass., Dec. 9, 1903.

Notes and Queries.

The address of Mr. Fritch, Secretary of the American Railway Engineering & Maintenance of Way Association, was given in our issue of Dec. 17 (p. 544) as Washington, Ind. This was incorrect; Mr. Fritch was formerly located at that place, but the offices of the Association are at 1562 Monadnock Block, Chicago.

A STEAM TRAP OPERATED BY A DIAPHRAGM.

The accompanying cut represents a form of steam trap whose valve is operated by a flexible diaphragm containing a volatile fluid. Between the body A and cover B is fitted the hollow diaphragm C, controlling the valve D by means of its expansion and contraction under varying temperature and pressures. The travel or movement of the diaphragm may be regulated by the thumb-screw E. All the parts are of phosphor bronze, with the exception of the thumb-screw and the pipe plug, which are of brass. The water of condensation is piped to the inlet, preferably at the bottom of the trap, the discharge being at the top. Upon reaching the partially balanced valve it causes this to open, allowing the water to escape past the two seats. The valve remains open until all the water has passed out, when a steam temperature of 211° to 212° vaporizes the fluid inside the diaphragm, causing it to expand and close the valve. The trap should be so connected that the diaphragm will be constantly submerged. There are three openings, one for the inlet and two for discharge, the most convenient of the latter being used and the other one plugged.



Steam Trap Operated by Flexible Diaphragm.
C. A. Dunham Co., Marshalltown, Ia., Makers.

The trap is designed to remain open for water and air, but to close against steam, and it will open wide or close tight on a variation of 1° in temperature. It is also claimed that this trap will work against a back pressure, discharging its water at a higher degree of temperature corresponding to the pressures against which it discharges. The valve as shown is designed for working pressures of 5 lbs. to 125 lbs., but for a wider range of temperatures and pressures a special valve is used in which the contraction of the diaphragm draws back the valve; this gives the valve a large travel when necessary. This pattern is especially adapted for heating work, cylinder jackets, ore and steam separators, etc. There is also a low-pressure trap, fitted with a by-pass. The trap is but little larger than a globe valve, but its capacity is large; its working parts are few, and it remains wide open when not in use, while it does not need to be level, and may be readily inspected by removing the cover, without disconnecting the pipes. The valve is ground in, and may be reground to a true bearing without removing the trap. It is said that the trap will not gum up or stick.

This steam trap is manufactured by the C. A. Dunham Co., of Marshalltown, Ia., and we are indebted to the makers for drawings and other information.

RURAL ENGINEERING.*

Rural engineering, as defined in Circular 45 of the Office of Experiment Stations, is "the science and art of laying out farms, designing and constructing farm buildings and works, and making and using farm implements and machinery."

A careful examination of existing conditions in the United States leads to a belief that there should be a strengthening of the courses of instruction in these subjects in our colleges, and the inauguration of comprehensive investigations and research work to ascertain the best practice in this and other lands and provide up-to-date information for instruction in our institutions of learning. This is equally true, whether the opportunities for students or the needs of the American farmers are considered.

The comparatively large areas of American farms makes the laying out and arrangement of the different fields a matter of especial importance to our farmers. In order to maintain the fertility of the soil, rotation of crops must be practiced. To do this fields should have such areas and such number as will make a regular system of rotation feasible. This gives an opportunity for the exercise of skill and intelligence, and, in connection with the building of roads leading from farm buildings to different parts of the farm, may involve marked economy or serious waste in the expenses of construction and in the distances traveled in going to and from the fields.

Closely related to the arrangement of fields is the construction and grouping of farm houses and farm buildings, not only to secure efficiency and economy, but to contribute to the healthfulness and attractiveness of farm life. There is no doubt that present conditions in these particulars in the United States are inferior to those in most European countries, and it is equally certain that improving the conditions of farm life will have much to do with determining whether the exodus of people from the country to the cities will be checked or become greater in the future than in the past.

In the construction of farm buildings, both barns and houses, the farmer is almost entirely dependent on his own knowledge and ingenuity in preparing plans and often in their execution. The great majority of farm buildings are unsatisfactory, whether considered from the standpoint of appearance, durability, adaptability to the work to be done, healthfulness, or pleasantness for the occupants. Some problems in connection with farm buildings need careful study. Among these is ventilation. The fact is we do not know either the effect of poor ventilation or the most efficient means of securing good ventilation. But the majority of the improvements to be wrought do not require research so much as the application of skill and ingenuity in design. One illustration of this is the fact that nothing is of more service in a home than a convenient water system. Much of the dislike which many women have to farm life comes, consciously or unconsciously, from the heavy work of handling water in cooking and washing, all of which could be easily saved by the adoption of readily available means. There is no reason why a farm house should not be as attractive as a city house, and there is no reason why the grounds surrounding farm houses should not be made as attractive as city parks. It is largely because farm life and the farm home are not attractive that many of the enterprising, aggressive youth of the country flock to the cities.

Heretofore nearly all farm buildings have been built of wood. A change in this direction is inevitable in the near future. Timber is becoming scarce and costly and must be supplemented by brick, stone, or concrete. We ought to begin in the near future to determine the relative value and cost of these different materials, and this is particularly a work for the colleges and stations. The character of farm buildings has also changed greatly in the last quarter of a century. Formerly they were simply storage places for grain or shelters for live stock. With the introduction of feed cutters, silos, power churns, centrifugal cream separators, and scores of other machines formerly unknown these buildings are becoming as complex in their design and uses as factories, and there is need of scientific study to determine the most economical designs to fulfill these different requirements.

Another reason for strengthening these courses of study is the fact that all of the public lands susceptible of cultivation in their natural condition have been taken up, so that this outlet for our growing population is closed. We have, however, large areas of land which, when drained or irrigated, can be settled upon and cultivated. The importance of irrigation is manifest from the statement that in two-fifths of the United States it is an absolute necessity to the existence of civilized life, and there is every reason to believe that it is destined to be an important means of increasing production throughout the whole country.

An excellent beginning in the study of these questions has been made in a few institutions and by the Office of Experiment Stations, but there is a great field for the extension of both instruction and research and for a broader coöperation between the department and the state institutions in both the cultural and engineering sides of this branch of agriculture.

Of wider application and scarcely less importance is the subject of drainage. The marsh and overflowed lands along our seacoast and the bottom lands bordering many of our rivers are at present unsightly, unproductive, and in some instances a menace to the health of surrounding districts. They need only to be diked and drained to be the most valuable lands in the country. The carrying out of these improvements will add immensely to the agricultural values of the country, and the work is certain to be undertaken in the near future. It involves, however, a larger knowledge of agricultural engineering than can now be obtained in our land-grant colleges. In fact, the profession of agricultural engineer, so prominent in Europe, is almost unknown in this country. Very little has been done in this country to develop a satisfactory drainage practice. The principles of drainage are understood by but few, and instruction in our colleges is meager and far from being up-to-date. Drainage laws are far from satisfactory and need to be modified because this work is beyond the means of individuals and must be carried out by organizations of large numbers of landowners associated under some definite legal plan.

Associated with drainage and irrigation is another branch of hydraulic agriculture whose importance has not been properly realized. This is the terracing and draining of hillside farms in order to protect them from the destructive effects of erosion. It is an unfortunate fact that much of the activity of the last century in subduing and settling this country has been of a destructive character. Forests have been cut from the headwaters of streams; the hillsides which they protect have been exposed to the erosion of storms, and the evils of the work done by rainfall have been aggravated by the planting of these lands to crops which require clean culture, such as corn, tobacco, and cotton, which provide no binding material for the soil. As a result, much of the accumulated fertility has been carried down into the channels of streams, thus leaving thousands of acres of what was fertile land not many years ago scarred with gullies and practically abandoned to weeds and brush. We must stop this destructive style of farming if we are to maintain the prosperity and provide an adequate food supply for many sections in the eastern half of the United States. To find out how best to do this and to encourage farmers to begin action is a work which both the Department of Agriculture and the different state experiment stations should take up at once. The hill lands of France, Germany, and England are as fertile as they were a century ago, although many of them are devoted to cultivated crops. The credit for these results is due to the existence of a body of trained agricultural engineers, a class of professional men not now existing in the United States. The time has come when our colleges should lend themselves actively to this sort of training. The opportunities for employment in irrigation, drainage, and hillside protection are sufficiently great to make it an attractive course to young men having aptitude for such work, and it is the field to which we must look for the largest results in the extension of our productive area and in the conservation of the fertility of much of the land now being farmed.

Another branch of rural engineering is the construction of country roads.

It is believed, however, that the greatest opportunities for students and for the improvement of the general agricultural practice of this country will be found in the systematic study of the manufacture and use of agricultural machinery in the world, and it is due largely to this fact that we have become the most prosperous agricultural country in the world. It has enabled the farmer to pay the high prices for labor created by the competition

*Report of the Committee on Rural Engineering of the Association of American Agricultural Colleges and Experiment Stations. Slightly Condensed from Circular No. 53, Office of Experiment Stations (A. C. True, Director), U. S. Department of Agriculture. The report was presented to and adopted by the association just named at its convention held at Washington, D. C., Nov. 17 and 19, 1903.

of our manufactories and has taken away from farm life much of the drudgery of manual toil and made it in the best sense an intellectual pursuit. Improvements in machinery have brought about a steady reduction in the cost of production, notwithstanding the steady rise in wages.

The demands which these changes are making on the farmer for a knowledge of the principles of mechanics and for a certain amount of skill in their application is so much greater than it was a century ago that it cannot be stated as a percentage. The question we have to consider is whether we have recognized this change in the courses of instruction in our agricultural colleges. Your committee is unanimously of the opinion that we have not, and that the facilities for instruction are not in keeping with the importance of this branch of agriculture. In the majority of institutions the same kind of mechanical training is given agricultural students as to students who expect to work in factories, while the work to be done by the farmer in the use of machines and tools is of a radically different character. On the farm one man must do many kinds of work and hence must use many different kinds of tools; in shops and factories one man does one thing or a few things only. This highly developed specialization produces efficient labor. A man uses a tool until he understands it thoroughly, recognizes immediately any defect, acquires a feeling of ownership in it, gives it constant care, and is often able to make improvements in its construction. All this is very different in the experience of the farmer. He uses one machine only a short time and then must take up another. What is learned about the construction and use of a machine at one time is largely lost before it is again called into use. The result of all this is that the farmer fails to develop that interest and mechanical sense which are necessary to the highest efficiency in the operation of the complex machinery which now forms a part of the equipment of every modern farm.

The records of the last census show that over one hundred million dollars worth of farm machinery is made and sold each year. The saving which would come to the people of this country by extending the life of each machine one year would be an immense addition to the annual profits of our farmers. This saving can be more than realized and it can be augmented by the greater efficiency which would come from expert care and management. At present it is notorious that the American farmer, with all his mechanical aptitude and inventive skill, is behind the other leading agricultural countries in his management and care of agricultural machinery. It is believed that this is largely due to the neglect of this subject in our schools. In Germany, France, and more recently in England, a well-equipped laboratory for testing agricultural machines and a museum filled with samples of machines of different patterns for examination by students is held to be as essential to proper instruction as a chemical laboratory. The first floor of the agricultural high school at Berlin contains a museum in which are found the best types of agricultural implements of the United States, England and Germany.

This training in the agricultural institutions of Germany is regarded there as of the highest value not only by farmers but by manufacturers. It gives them trained workmen in their shops; it gives them trained agents to extend their export trade in different countries. The union of agricultural and mechanical knowledge in their employees and agents has enabled German implement makers to greatly increase their export trade, and it is believed that the same result would follow similar training here. If we are to maintain our standing as a producing and manufacturing nation we must maintain our superiority as designers and users of farm machinery, and this can be best promoted by bringing the trained intelligence of the experts of the Department of Agriculture and of the students and professors of our agricultural colleges to bear on this problem. A few colleges have created departments for instruction in certain branches of rural engineering, the departments of irrigation engineering in Colorado and California being illustrations of this, and a number of colleges are now considering the establishment of courses in rural engineering with farm mechanics as the leading feature, and there is much interest in the development of these courses as independent lines of work. Among these are the colleges of agriculture in Illinois, Wisconsin, Minnesota, Iowa and North Dakota.

The same policy should be followed in the organization of the work of the Department of Agriculture. This department is now doing important and useful work in a number of branches of rural engineering, but its influence on the development of the country and the effectiveness of the investigators would be greatly promoted if all of these related lines of work were gathered together in one division, instead of being made simply incidents of the work of several bureaus organized to do other things, as is now the case. It is believed that the importance of these subjects warrants the adoption of this plan at an early date. One of the reasons for believing this is the consideration given to these subjects in other countries where their importance is far less than with us. The bureau of hydraulic agriculture is one of the leading bureaus of the agricultural department of France. It includes only drainage and irrigation. The relative importance of these subjects in France and this country is shown by the fact that France has only 400,000 acres of irrigated land, while we have nearly 8,000,000 acres irrigated and the work is still in its infancy. In France irrigation is not a necessity—only an aid to agriculture. In two-fifths of the United States it is a necessity for civilized life.

Over 8,000,000 acres of sagebrush desert land has been reclaimed by the unaided efforts of farmers, without any assistance from either the federal government or the states, in such a manner as to produce good crops. This task is one of the greatest achievements of the agricultural classes of this or any other continent. It has involved an amount of experimenting and a waste of money in failures and partial failures which is inconceivable to those not practically familiar with western conditions. This task, however, has not been completed. Some of the most difficult problems yet remain to be solved. Some of the things which remain to be done are to determine the amount of water which each farmer should receive, and to provide for an equitable distribution of the waters of streams.

The watering of 8,000,000 acres of land involves the handling of an enormous quantity of water each year. If this water could be transferred from the streams to the field with the same system and skill that is exercised in the operation of some of our railroads, or that is shown in the distribution of water in some of the best districts of Italy and France, the gain in the saving of water and in the increased production of crops would be something enormous. At present in many parts of the West there is either a very defective system or no system at all, and a competent investigator has estimated that we are losing each year at least $10,000,000 on account of the faulty distribution of appropriated waters. These figures are sufficient to show the necessity for a systematic study of these questions by the Department of Agriculture and to show also why, with the increase in the cultivated area which is each year going on, the necessity for these investigations and their importance to the whole country is destined to increase.

There is no country where drainage problems are as important as in the United States. The swamp and overflowed lands of this country if reclaimed will equal in productive capacity practically the whole of France, yet the problems of drainage and diking, on which their successful reclamation depends, have as yet received but little study, and the practice in both directions is susceptible of great improvement.

The construction of country roads is an essential feature of rural engineering. The great extent of our country, its recent settlement, and the necessity for extensive improvements in those directions make it an important factor in the work of the Department of Agriculture. The necessity for improvements in roads has been referred to above, but the study of the character of these improvements involves also a study of the kind of machines and vehicles that are to travel on them. Along with the study of road making should go a study of the limitations and requirements of traction engines, automobiles, and all of the new forms of transportation which are becoming an essential factor of American farm life. The relation of the problems of farm machinery to irrigation and drainage has already been shown by the necessity of including in these investigations a study of the applications of power to pumping, because pumping is the only means of supplying water for irrigation in certain districts and an essential means of removing water from over-irrigated lands in others. The study of pumping has, of necessity, led to a study of the relative economy and effectiveness of different forms of power for the operation of pumps. There is equal need of similar studies of the applications of the different forms of power, whether steam, gasoline, electricity, water, or wind power in the other branches of farm work, and these are being brought home each year with increasing force to both the manufacturers and users of farm machinery. We believe, therefore, that all these related lines of work should be brought together in the Department of Agriculture in a single bureau, exactly as all the related lines of instruction in these subjects should be brought together in one distinct course in our colleges.

The necessity for increased attention to those subjects has been recognized by both the Secretary of Agriculture and the Director of the Office of Experiment Stations. Dr. True has recommended that the name "irrigation investigations" be changed to "irrigation and agricultural engineering" in order to more correctly indicate the nature of the work being done, and the Secretary of Agriculture, on the recommendation of Dr. True, has included in his estimates to Congress a request for this change and for an increased appropriation to be expended in making investigations in the applications of power to farm machinery, the direction of these inquiries, as indicated in Dr. True's report, to be:

(1) Preliminary work in the collection and publication of information regarding the evolution, character, and use of farm implements and machinery in this and other countries. This is important because the available literature on the subject is scattered, fragmentary, and out of date. A small beginning has just been made in this direction in a bulletin on "The Evolution of Reaping Machines," recently published by this office, and another bulletin describing corn-harvesting machinery, which is being prepared.

(2) Laboratory and practical tests, involving a study of principles of construction and methods of operation of farm implements and machinery with special reference to efficiency and economy. These might very properly include certain strictly technical inquiries regarding the fundamental nature of the various mechanical farm operations with a view to suggesting the best means of performing them with the implements and machines at present available, or with others, the construction of which will be indicated by the results of the inquiries. Such inquiries would require considerable laboratory equipment, but the results obtained would be useful to the farmer by securing for him the most efficient implement or machine for performing the desired operation, and to the manufacturer by assisting him in the construction of the desired implements and machines.

This committee recommends that the association declare itself in favor of the creation of separate departments of rural engineering in the colleges, that it give its hearty support to the efforts of the Secretary of Agriculture to extend the work of his department along these lines, and that the executive committee be instructed to urge upon Congress the importance of giving the department liberal appropriations for these purposes.

W. E. Stone, A. R. Whitson, Samuel Fortier, C. F. Curtiss, Elwood Mead, Committee.

A TRACK CIRCUIT BLOCK SIGNAL FOR ELECTRIC RAILWAYS.

An automatic track circuit signal system for use on electric railways was given a successful demonstration last week before a party of Eastern signal engineers, at Rochester, N. Y. It represents the first solution of a very important problem: the problem of protecting an electric railway line by automatic block signals operating in the manner which has been found best in regular railway operation. The means by which this result is reached are but little more complex than those used in steam railway signaling.

As is well known, the principle of automatic block signaling is to divide the railway into sections of suitable length, say one-half to one mile long, and to arrange means for shifting a signal arm placed at the entrance of each section or "block" so as to indicate whether or not that block contains a train. As a detector, to reveal the presence of a train in the block, the track circuit is universally used: An electric battery is connected across the rails of the block, each rail being separated from the adjacent block by an insulating rail joint; an electromagnet, also connected across the rails, is energized by the current from this battery and actuates directly or indirectly the mechanism for moving the signal arm to the position denoting safety or "Clear." When a train is in the block, its wheels and axles short-circuit the battery current passing through the rails, and the electromagnet (called the "relay") is then de-energized and allows the signal arm to return into the "Danger" position. In this system, it will be noted, any break in the continuity of the rail, or any failure in any part of the apparatus, will de-energize the relay magnet and give a "danger" indication. This so-called Normal Danger method of signaling is generally considered absolutely essential in automatic block signaling. One of the prime features of the new system for electric railways is that it is a Normal Danger system; in fact, its operation is precisely similar to that outlined above.

The point of difficulty in applying automatic signaling to electric railways has been the fact that the two track rails are employed as return conductor for the trolley current. It seems impossible, therefore, to utilize the rails for a track circuit which shall indicate the condition of the block, without removing the trolley return current from one of the rails. We use the word "seems" because the successful working of the new system proves that it is quite possible and practicable. Before describing this system we may mention that one way of getting around the difficulty referred to has been to employ only one of the two track rails for the trolley return, leaving the other rail free for the track circuit, the return for which may obviously also be through the trolley return rail. It is then possible to divide the free or "block" rail into insulated sections or blocks, each fed by a battery, thus establishing an independent track indicator circuit in each block. This plan has the defect that it just halves the cross-section of conductor available for the trolley current return, and for this reason will usually necessitate installing heavy copper return feeders to assist the rail. The extra expense of these feeders being directly chargeable to the signal installation, makes the cost of the signals prohibitively high. Another method which has been advocated is to place a small insulated metal strip

along the track near one of the rails, this strip being arranged to make contact with a metal brush projecting from the car truck or axle. The signaling circuit then passes through this strip, and the operation is the same as in the regular signaling. Obviously, aside from other disadvantages, the cost of the signaling strip adds very materially to the cost of the signals.

The new method, called the Young System, leaves both rails available for the trolley return, and yet utilizes the rails for the indicating track circuit. Briefly, it involves nothing more than the substitution of an alternating signaling current for the ordinary battery current. Necessarily, also, the separation between successive block sections

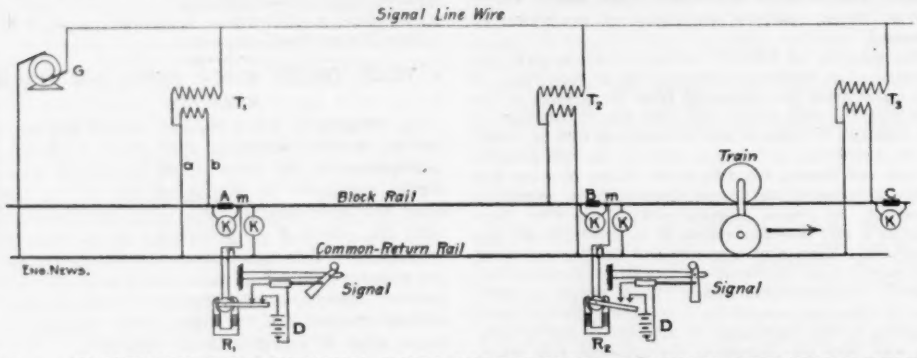


FIG. 1. AN AUTOMATIC BLOCK SIGNAL SYSTEM FOR ELECTRIC RAILWAYS: THE YOUNG TRACK CIRCUIT.

cannot be simply by the usual insulating joint, since this would prevent the trolley return current from passing, but must be accomplished by a device which gives free passage to the trolley return while serving as insulator for the alternating signaling current. A further requirement is that the electromagnetic relay must be such as to be actuated by alternating instead of direct current.

The arrangement of apparatus used to carry out this idea is shown in the wiring diagram accompanying. One of the two track rails is divided by insulating joints A, B, C, into consecutive blacks A B, B C, etc. At the entrance of each block trains assumed moving to the right in the diagram) is placed a signal mast, whose arm may be operated either by compressed air or by electric motor, in the usual manner. In our illustration a small battery, D, is shown supplying the motor mechanism of the signal arm; the circuit of this battery is controlled by a relay, R, and when closed, as at R_1, the signal arm is pulled down into the inclined position indicating "Clear," while when the circuit of D is open, as at R_2, the signal arm is pulled by a counterweight into the horizontal or "Danger" position.

The signal circuit current is supplied by a small alternating current generator, G, in the power house or substation. This machine supplies current at 300 volts and 100 cycles to a line wire strung along the line of the railway. The power transmitted over this wire is always quite small. At the far end of each block there is a small step-down transformer, T, which supplies a 3-volt alternating current to the preceding block (by the wires a b in the diagram. The 300-volt side of the transformer is connected to the unbroken or common return rail. Each block, therefore, has an alternating potential of 3 volts impressed across the rails at the far or leaving end of the block.

At the entering end of each block the indicator wires m n, leading to the relay, are taken off. The relay itself is virtually a small alternating current motor adapted to be operated by the 3-volt track circuit current from m n. It may be constructed in various ways. In the demonstration of the system the relay was arranged with separately-excited field windings, supplied from suitable connections to the line-wire. In any case, its action is such that when current flows in the track circuit, the armature of the relay will tend to rotate, and thereby presses a contact arm against two contact points in the local circuit of the signal mechanism. When no current passes in the track circuit, the contact arm drops away from its contact points and opens the circuit of battery, D, thereby giving a "Danger Signal." Evidently this occurs when a train in the block (as in block B C) short circuits the track circuit from wires a b.

It will be noticed that the block rail is broken by insulating joints A, B, C, etc. In order to usefully employ this rail for part of the trolley return circuit these insulating joints are shunted by special bonding devices marked K, which offer free path to the direct current of the trolley return, but oppose a high resistance to the passage of the alternating signaling current. The nature of these devices, K, was not disclosed in the public demonstration of the system, for reasons of patent application. It would seem, however, that a suitably designed reactive or choking coil would fulfil the requirements of the case, and for our present purpose we may consider the bonds, K, to be merely choking coils. The passage of the trolley return current through such coils will depend only on their resistance, which may be made as low as desired, while the resistance offered to the flow of alternating current depends upon their electromagnetic inductance. We may assume that they make the block rail electrically continuous for the trolley return, but divide it into blocks as regards the alternating signaling current. A second such bond, K, is connected between the block rail and the common rail at each block point, to supply the desired cross-bonding of the track without short-circuiting the signaling track circuit.

The operation of this signal system will be clear from what has already been said. It is exactly the same as that of the track circuit system of the ordinary automatic block signal. One additional feature deserves to be mentioned: the 3-volt supply wires a b are connected in reverse polarity in consecutive blocks, as is indicated at A and B in the diagram. The purpose of this is to give a "Danger" indication when one of the insulated joints breaks down. Suppose, for instance, that joint B loses its insulating powers. Then the secondary current of transformer T_3 has free passage into block B C, and if a train be in the position shown it would not fully short circuit the relay R_2, since current from T_3 could reach this relay. In this condition, if the track circuit of adjacent blocks had the same polarity, a second train reaching B would get a "Clear" signal even though a train is in block B C. With the reversed connections of the leads a b in successive blocks this cannot occur: if joint B breaks down the current from T_3 will flow across the joint and act upon relay R_3 in the reverse from normal direction; it thus throws R_3 sharply open and gives a "Danger" indication.

In regard to the details of the system as developed, we may mention that the generator, G, is about 2 KW. in capacity, and will supply 15 to 20 miles of way, or say 30 to 40 signals. The transformers, T, take each 20 to 30 watts, and have a capacity of 50 watts. They are designed with low regulation, the secondary voltage falling off rapidly as the load increases, which adds to the certainty of action of the relays and prevents damage from short circuits. The relays are extremely sensitive and will work with a potential of 0.1-volt. It is claimed that this fact, together with the use of alternating current for the track circuit, will enable this system to operate under conditions which put out of service most automatic block signals.

The Young system was conceived by Mr. S. M. Young, of the Pneumatic Signal Co., Rochester, N. Y., and was developed with the assistance of the engineers of that company and Mr. Fitzhugh Townsend, of New York city. It is being made by the Pneumatic Signal Co. for use with any form of signal mechanism, whether pneumatic, electro-pneumatic, or all-electric. In the demonstration which was given on Dec. 18 on the Sodus Bay line of the Rochester Railway Co., the company's all-electric signal arm mechanism was employed, in which a motor operates the signal arm through gearing. For the local circuit of the signal mechanism current was taken from the trolley (600 volts) and passed through five incandescent lamps fixed on the signal arm to illuminate it. After passing through the lamps the circuit went to a small six-cell storage battery, which latter in turn supplied the signal motor under the control of the relay. This is probably the most compact arrangement possible for electric railways.

It is stated that the Young system may be applied quite readily to the alternating current railway, upon the advent of the latter. It is necessary only to select the signaling track circuit of suitable frequency to avoid interference with the power-current.

FINAL REPORT OF THE COMMISSION ON ADDITIONAL WATER SUPPLY FOR THE CITY OF NEW YORK.

For $98,839,000 the City of New York can be provided with a daily supply of 500,000,000 gallons of filtered water, delivered by gravity through a high level aqueduct to a large reservoir at the north end of the city at an elevation of 295 ft. above tide water, thus supplying the highest parts of the city by natural pressure. For $60,098,000 a daily supply of 320,000,000 gallons, under like conditions, can be provided. Such are the estimates of Prof. Wm. H. Burr and Messrs. Rudolph Hering and John R. Freeman, Members Am. Soc. C. E., in their final report on an additional water supply for New York City.

The preliminary report of the commission was published in full in Engineering News of Oct. 1, 1903. The final report was recently completed, and we are indebted to the commission for an abstract of it, and for a map showing the location of the various reservoirs, the filters and the aqueduct. The map, somewhat simplified, is reproduced herewith. The brief abstract of the final report covers much the same ground as did the long preliminary report, but the final report contains conclusions and estimates of great interest.

The commission was instructed to report on water waste restriction, as well as on an additional supply. It advises that the investigations of consumption and waste, under the immediate supervision of Mr. Nicholas S. Hill, Jr., Chief Engineer of the Department of Water Supply, Gas and Electricity for Manhattan and the Bronx, be continued,

and that a system of thorough inspection should be installed, as well as a large extension of meters, not only in buildings, but also so placed upon the street mains as to divide the city into districts, the quantity of water flowing into each being measured. By these means it is believed that the greatest possible reduction in waste will be attained. As a matter of fact, the present investigations do not show nearly as much waste as has sometimes been anticipated. The leakage from street mains has so far been found to be small, the chief waste appearing to arise from leaky fixtures and defective plumbing in buildings. The total actual amount of leakage and waste discovered scarcely exceeds about 40,000,000 gallons daily for the Boroughs of Manhattan and the Bronx. As the consumption of Manhattan and the Bronx at the present time is about 285,000,000 gallons daily, that waste represents about 15% of the consumption.

THE PROPOSED GRAVITY SUPPLY.—The general outline of the plan for a new gravity supply, with a summary of the estimates of cost, is presented in the abstract of the report as follows:

The Commission favors taking a first instalment of 60,000,000 gallons from the Fishkill watershed, but developing concurrently the supply from Esopus creek. These two sources would give nearly 320,000,000 gallons per day. Another 100,000,000 gallons per day may be secured from Rondout creek without great additional expense, making a total supply of nearly 420,000,000. The final 80,000,000 gallons or more may be obtained from Wappingers creek by means of a large reservoir at Hibernia, within the drainage area of that creek, thus completing the amount of 5,000,000 gallons per day. If it should be desired, a further large supply can be obtained from the upper watershed of the Jansen Kill, on the easterly side of the Hudson, and from the upper waters of Schoharie creek diverted into the watershed of the Esopus creek, and from Catskill creek.

The waters of the three creeks on the easterly side of

the river are much harder than the Croton water, but the waters of Rondout and Esopus creeks are remarkably soft and desirable for city supply. It has been the Commission's plan to deliver to the city the soft waters of the Catskill mountain streams, so as to reduce the hardness of the combination with the waters on the easterly side of the Hudson, thus securing a supply equally soft as the Croton water.

The Commission is strongly of the opinion that after the waters of the streams now recommended for use are taken, Hudson River water should be secured by pumping it out of the river near Hyde Park up to suitable reservoirs and filters on the high land easterly of the river, so as to deliver it to the city at the required elevation. This, however, is in the remote future, and is set forth as a resource in reserve at that time. In such a development it will be necessary to build large storage reservoirs in the Adirondacks, from which flood waters of the Adirondack streams may be released during the summer flow of the Hudson, so as to prevent any salt water from reaching the point where the pumps would take the river water. It is explicity stated in the report that the filtration of Hudson River water would render it entirely satisfactory for all purposes.

. . . . . .

SUMMARY OF COSTS.—The works recommended to be constructed first comprise a section of the Hill View Reservoir, of 600,000,000 gallons capacity; the main aqueduct, of 500,000,000 gallons daily capacity, from that reservoir to Stormville Reservoir; a section of the Stormville filters, of 50,000,000 gallons daily capacity; the twin aqueduct, one channel of 400,000,000 gallons and the other of 250,000,000 gallons daily capacity, from the Stormville Reservoir to the Billings Reservoir and these two reservoirs. This construction will afford an additional supply of 60,000,000 gallons per day. Concurrently with the preceding construction, the aqueduct of 400,000,000 gallons daily capacity should be built from the Billings Reservoir to the Ashokan Reservoir, and at the same time the latter reservoir should also be under construction.

It is estimated that the first part of this work, i. e., extending from Hill View Reservoir to Billings Reservoir, may be built, under efficient management, within five years, and that the second part of the construction, extending from Billings Reservoir to the Ashokan Reservoir, may be completed within the same period, if the labor market affords sufficient force and the money is provided.

The summary of costs of this construction is as follows:

RESERVOIRS.

Hill View covered reservoir first section of 600,000,000 gallons capacity	$9,059,000
Stormville filter plant first installation of 50,000,000 gallons daily capacity	3,581,000
Stormville reservoir, 10,000,000,000 gallons capacity	2,503,000
Billings reservoir 6,800,000,000 gallons capacity	1,806,000
Ashokan reservoir, 66,500,000,000 gallons capacity	11,734,000
Total	$28,683,000

HIGH LEVEL AQUEDUCT.

From Hill View to Stormville filters	$18,755,000	
From Stormville to Billings, twin aqueduct	3,584,000	
From Billings to Ashokan, including Hudson River crossing.	9,076,000	
		31,415,000
Total cost of construction		$60,098,000

These estimated costs include actual contract and all other expenditures, except those for damages to water rights. These works will afford an additional supply of nearly 320,000,000 gallons daily.

It is estimated that the complete construction of reservoirs, filters and aqueducts for the full additional supply of 500,000,000 gallons per day may be required by 1925. The costs of the remaining construction in excess of that already provided for will be as follows:

RESERVOIRS:

Hill View Reservoir completed to 2,030,000,000 gallons in 1925	$4,110,000
Stormville filters completed to 500,000,000 gallons daily capacity in 1925	11,065,000
Hibernia Reservoir, 30,500,000,000 gallons capacity	9,308,000
Silvernails Reservoir, 17,200,000,000 gallons capacity	5,530,000
Total	$30,013,000

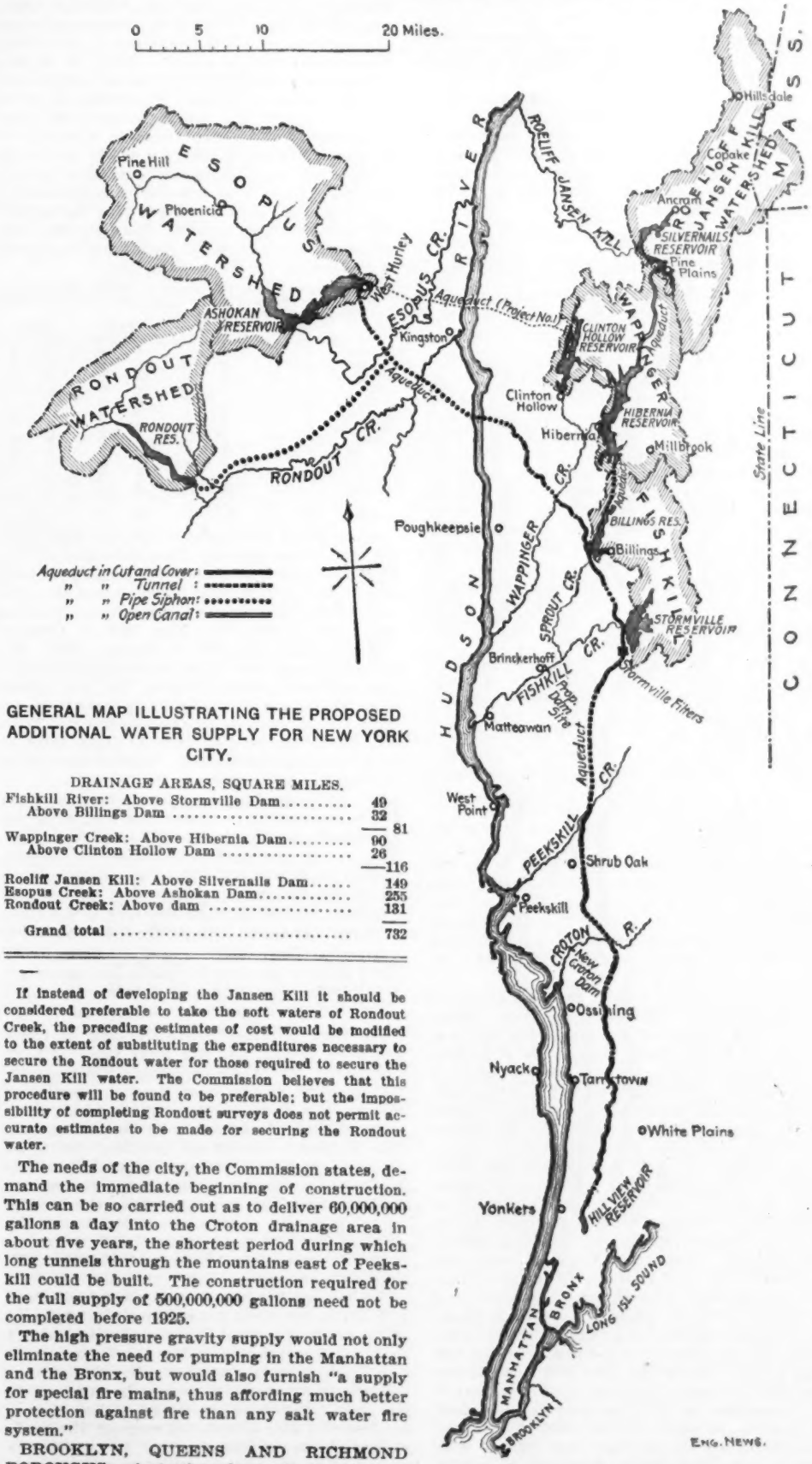
AQUEDUCTS.

Additional cost for completed aqueduct betwen Hill View and Stormville	1,510,000	
Additional cost for completed aqueduct between Billings and Ashokan	4,369,000	
Aqueduct from Billings Reservoir to Hibernia Reservoir, 300,000,000 gallons daily capacity	1,573,000	
Aqueduct from Hibernia to Silvernails, 220,000,000 to 330,000,000 gallons daily capacity	1,276,000	8,728,000
Total cost of additional construction is		$38,741,000

These additional costs, like those covering the first portions of the work to be constructed, include all expenditures such as those for land, clearing reservoir sites and other similar costs except water damages along the streams from which the additional supply is taken.

The total cost of the entire works required to deliver the additional high service supply of 500 million gallons per day will be the sum of the two preceding totals:

Total cost of entire work.....$98,839,000



GENERAL MAP ILLUSTRATING THE PROPOSED ADDITIONAL WATER SUPPLY FOR NEW YORK CITY.

DRAINAGE AREAS, SQUARE MILES.

Fishkill River: Above Stormville Dam	49	
Above Billings Dam	32	
		81
Wappinger Creek: Above Hibernia Dam	90	
Above Clinton Hollow Dam	26	
		116
Roeliff Jansen Kill: Above Silvernails Dam	149	
Esopus Creek: Above Ashokan Dam	255	
Rondout Creek: Above dam	131	
Grand total	732	

If instead of developing the Jansen Kill it should be considered preferable to take the soft waters of Rondout Creek, the preceding estimates of cost would be modified to the extent of substituting the expenditures necessary to secure the Rondout water for those required to secure the Jansen Kill water. The Commission believes that this procedure will be found to be preferable; but the impossibility of completing Rondout surveys does not permit accurate estimates to be made for securing the Rondout water.

The needs of the city, the Commission states, demand the immediate beginning of construction. This can be so carried out as to deliver 60,000,000 gallons a day into the Croton drainage area in about five years, the shortest period during which long tunnels through the mountains east of Peekskill could be built. The construction required for the full supply of 500,000,000 gallons need not be completed before 1925.

The high pressure gravity supply would not only eliminate the need for pumping in the Manhattan and the Bronx, but would also furnish "a supply for special fire mains, thus affording much better protection against fire than any salt water fire system."

BROOKLYN, QUEENS AND RICHMOND BOROUGHS.— As to these boroughs, the abstract of the final report says:

For Brooklyn and Queens, an immediate development of the ground water sources of Queens and Nassau counties is recommended, and that all surface supplies be filtered, also that ultimately these Long Island sources be supplemented by a branch conduit from the proposed 500,000,000-gallon aqueduct from the north of Manhattan.

For Richmond, the Commission has approved of a ten-year contract with a private company for the immediate introduction of filtered water from New Jersey.

Queens, the Commission says, already urgently needs more water, and

the Borough of Brooklyn has also reached that point where it must have additional water of good quality. It has already begun to filter its present surface supplies, which are more or less polluted by the increasing population of the southern portion of Nassau County.

The Commission takes a strong stand on the value of well-chosen underground waters, points

out the high character and large amount of underground water stored by nature on Long Island, and mentions briefly the large amount of work done under its direction in the way of studies of these underground sources. These studies have covered 1,000 sq. miles of territory, and have included observations of the water levels in nearly 1,500 wells.

FILTERED WATER FOR THE WHOLE CITY.—The Commission

practically asserts that at the present time no municipality can be considered satisfactorily supplied with water unless that supply is either filtered artificially or naturally as in the case of ground water.

Its recommendations include an ultimate filtered (natural or artificial) supply for the whole city, and it strongly urges that works for the filtration of the Croton supply be begun at once. It also advises that the reservoirs in Central Park be cleaned and that they be roofed over as soon as the Croton supply is filtered.

THE TYPHOID FEVER EPIDEMIC AT BUTLER, PA.

By George A. Soper, Ph.D., Assoc. M. Am. Soc. C. E.*

INTRODUCTION.

The first news that an epidemic of typhoid fever had settled upon Butler appeared in the daily papers about the middle of November. In the two weeks following this announcement, details were published of the most sensational character. Press despatches announced that nearly a thousand persons had been stricken in a community of sixteen thousand. The number of cases increased daily, and the citizens were in fear that worse conditions were yet to come. Then followed a fortnight during which the news from Butler was confusing and contradictory. Apparently the causes of the epidemic, the measures which were being taken to suppress it and the needs of the suffering people were either not clearly understood or improperly made known.

On Dec. 12, 1903, the management of Engineering News requested the author to go to Butler and investigate the facts. Accordingly, on Dec. 13, the journey was undertaken. Five days were spent upon the ground. Ample facilities for a thorough and impartial investigation existed, and assistance was freely offered by the people. Books and records were opened for inspection; the operation of the municipal government, the activities of the citizens' relief committees, the prosecution of the campaign of the state board of health, and the details of management of the water company before and during the epidemic were generously exhibited by those who had these matters in charge. It is thought that the essential features of the situation were thoroughly inquired into. The information was obtained almost exclusively at first hand.

It at once became evident that the extent of the epidemic had not been exaggerated. About one in every thirteen of the population was sick. Succor was being offered to hundreds of families in distress by a committee of citizens elected in mass meeting. The state board of health had initiated extensive measures to prevent the fever from gaining further headway. Various associations from other cities were sending aid.

The cause of the epidemic is clearly the water supply. Owing to the failure of a dam, the water had been drawn since last August from the Connoquenessing Creek at a point at which it was obviously polluted. The supply had been filtered until Oct. 20. On that date the filters were shut down and kept out of service until a pipe connection could be made between some new pumps and the basin for filtered water. It could not be ascertained that any warning had been given to the public that the water from the polluted creek was being pumped during this time, and it is improbable that the water company considered that it was dangerous for drinking purposes. In fact, the families of some of the employees of the water-works are among those most afflicted with typhoid fever. The filters were out of service from Oct. 20 to 31. The epidemic broke out about Nov. 2.

*Consulting Engineer and Sanitary Expert, 29 Broadway, New York City.

The main facts brought out in the investigation are herewith presented in detail.

LOCATION AND MUNICIPAL CONDITIONS AT BUTLER.

Butler, Pa., is a community of about 16,000 inhabitants, and lies in the western part of Pennsylvania, 49 miles north of Pittsburg. It is the county seat of the county of Butler, and was founded one hundred years ago, when the county was established. The form of government is that of a borough, which, in Pennsylvania, is in many respects like that of a city. There is a chief burgess, who corresponds to a mayor, and a council and board of health. The members of the board of health are five in number and serve gratuitously. The board employs a health inspector at $50, and a secretary at $30, per month.

There are no reliable vital statistics to show whether typhoid fever has ever been prevalent or not in Butler, but it is believed that the borough has been generally healthy. The following data, admittedly incomplete, are taken from the records of the Butler board of health:

Records of the Butler, Pa., Board of Health, Showing the Number of Typhoid Fever Cases and Deaths Recorded from 1900 to 1903, Inclusive.

	1900		1901		1902		1903	
	Cases.	D'ths.	Cases.	D'ths.	Cases.	D'ths.	Cases.	D'ths.
January..	0	0	1	0	0	0	1	0
February	2	0	0	0	0	0	0	1
March...	0	0	3	0	0	0	1	1
April....	0	0	4	0	0	0	0	3
May.....	1	1	0	0	0	0	0	1
June.....	1	0	4	1	0	0	0	1
July.....	9	0	2	0	3	2	0	0
August...	2	0	3	0	5	0	0	0
Sept'mb'r	9	2	5	0	2	0	0	0
October..	7	1	6	0	11	0	0	0
Nov'mb'r	9	1	0	0	2	2	..	..
Dec'mber	2	2	0	0	3	0	..	..
Total	42	7	28	1	26	4	..	..

Imperfect as these records are, the figures are not without significance. They show that typhoid fever has existed at Butler, and possibly at some periods to a considerable extent, before the present season. There seems to have been something like a run of fever from May, 1900, to January, 1901, and from July, 1902, to January, 1903. The number of cases recorded is not high for a population as large as that of Butler, but it is certain that the records of the board of health do not show all the cases which have occurred. There may have been several times as many cases as have been officially notified. There is no way by which an accurate estimate can be made.

The following figures represent the cases and deaths recorded by the Butler board of health for November and December, 1903, and well illustrate the incompleteness of the official returns. It will be remembered that the epidemic broke out in the first week in November and that by December 11 there were considerably over a thousand cases, as shown by house-to-house canvasses.

	Cases.	Deaths.		Cases.	Deaths.
Nov. 1 to 6...	3	1	Nov. 28 to Dec. 4 ...	61	17
Nov. 7 to 13..	0	1	Dec. 5 to 11.	52	11
Nov. 14 to 20.	36	14			
Nov. 21 to 27.	3	0	Total....	155	43

The town is rather compactly built of frame and brick houses, and has eight miles of brick pavements. There are ordinances which specify that property owners must clean the portion of the street in front of their property and cause accumulations of garbage to be removed at least once a week. Sewers are provided for house drainage only; it is estimated that 80% of the dwellings are connected with them. The sewage discharges into the Connoquenessing Creek. The following nearby communities draw their water supplies from the same stream, after it has received Butler's sewage: Zelionople, Harmony, Elwood City and Beaver Falls.

The borough is situated at an altitude of about a thousand feet above the sea, on a rise of ground in the midst of a broad valley almost surrounded by hills. Through this valley the Connoquenessing Creek flows in a southerly direction to meet the Beaver River, which ultimately empties into the Ohio. The creek at Butler is less than a hundred feet wide at ordinary stages. The headwaters of the Connoquenessing lie within the county of Butler and consist of numerous small brooks or runs. The drainage area is for the most part hilly, and the runoff rapid. Three small villages and perhaps one hundred and fifty scattered families are located in the country which is drained by the brooks. The people live by farming and by industries connected with the oil and gas wells and coal mines for which the district is well known.

Within the last three years Butler has had a remarkably rapid growth in population. From a community stated by the United States Census of 1900 to contain 10,853 inhabitants, it has to-day between sixteen and eighteen thousand. The borough has had several booms on account of discoveries of petroleum, natural gas and coal in its neighborhood, but no sudden wave of prosperity in its history can be compared with the recent one.

The growth of Butler since 1900 has been due to the establishment of several large industries. Chief among these are the works of the Standard Steel Car Co., at Lyndora, a small settlement adjoining Butler. The car works were built two years ago. They at once brought 3,000 operatives, their families and a considerable following to the place. To accommodate the sudden influx of residents, hundreds of houses were built.

The rapid expansion of population made itself felt in many ways in the municipality, but in no direction more conspicuously than in the water supply. The demand for water increased more rapidly than the population. The books of the Butler Water Co. show that the consumption of water in the last week in November, 1901, was 10,000,000 gallons; for the same week in 1902, 12,000,000 gallons; and for the same period in 1903, 19,000,000 gallons. That is, while the population increased about 50%, the consumption of water increased nearly 100%.

OUTLINE OF THE SYSTEM OF WATER SUPPLY.

The water supply of Butler (see Figs. 1 and 2) has been obtained from the Connoquenessing Creek since the establishment of water-works by the water company in 1878. There is a pumping and filter station on the banks of the creek near the borough line. At this point the water, under ordinary circumstances, is received from mains which bring it from a distance. It is then filtered and pumped to an open reservoir of 2,500,000 gallons capacity, situated on a neighboring hill. The water flows from the reservoir to all parts of the borough.

It is said that the point of intake of the water supply was for some years located at the pumping and filter station, and this intake is now in condition for emergency use. To avoid pollution by oil and salt wells, and to obtain a water which would be more acceptable in other respects, a rude earth dam was constructed some years ago across the Connoquenessing Creek, near the village of Boydstown, seven miles above Butler. A line of vitrified pipe was laid to carry this water to the pumping and filter station.

The dam at Boydstown impounded 130,000,000 to 140,000,000 gallons of water, but it appears that this reservoir was not sufficient to meet the needs. Consequently, a year ago, an impounding reservoir was laid out on the chief tributary of the Connoquenessing, called Thorn Run. A dam was built on this stream to impound 300,000,000 gallons of water. It was expected that the service from Thorn Run would be available in the early fall of 1903; in fact, it appears that the dam was completed and the water main to the pumping station laid before the first of November, but that this source remained unavailable for the want of rain.

THE FILTER PLANT.

It is understood that the Butler Water Co. is now controlled by the American Water-Works & Guarantee Co. of Pittsburg, which is said to operate nearly forty water-works in all, including sixteen or seventeen which have filters. The filter plant at Butler was designed and built by the last-named company since it obtained control of the works. The plant consists of six open gravity filters of 15 ft. diameter and 8 ft. depth. They are built of steel and contain 6 ins. of gravel and 4½ ft. of a natural, round-grained quartz sand, obtained from Red Wing, Minn. Each filter is operated separately.

The pressure necessary to cause the water to pass downward through the sand is obtained by carrying the filtered water outlet down several

feet below the bottom of the filter tank, the principle of operation being that of a siphon. The maximum pressure which is thus made available for the purpose of filtration is about 12 ft. A butterfly valve in the supply main of each filter, operated by a float located in the water above the sand, prevents the filters from overflowing.

The filters are washed by a reverse flow of filtered water, introduced under the sand. The impurities which are thus flushed out are carried away by drains.

It is said that a coagulant, basic sulphate of alumina, is ordinarily used, being introduced into the water just before it enters the filter house. The solution of coagulant is made up by adding a measured weight of chemical to a tank of water of known volume.

After passing through the filters the water is received in a concrete basin situated under the filter house. The basin measures 80 × 40 ft., and is 9 ft. deep.

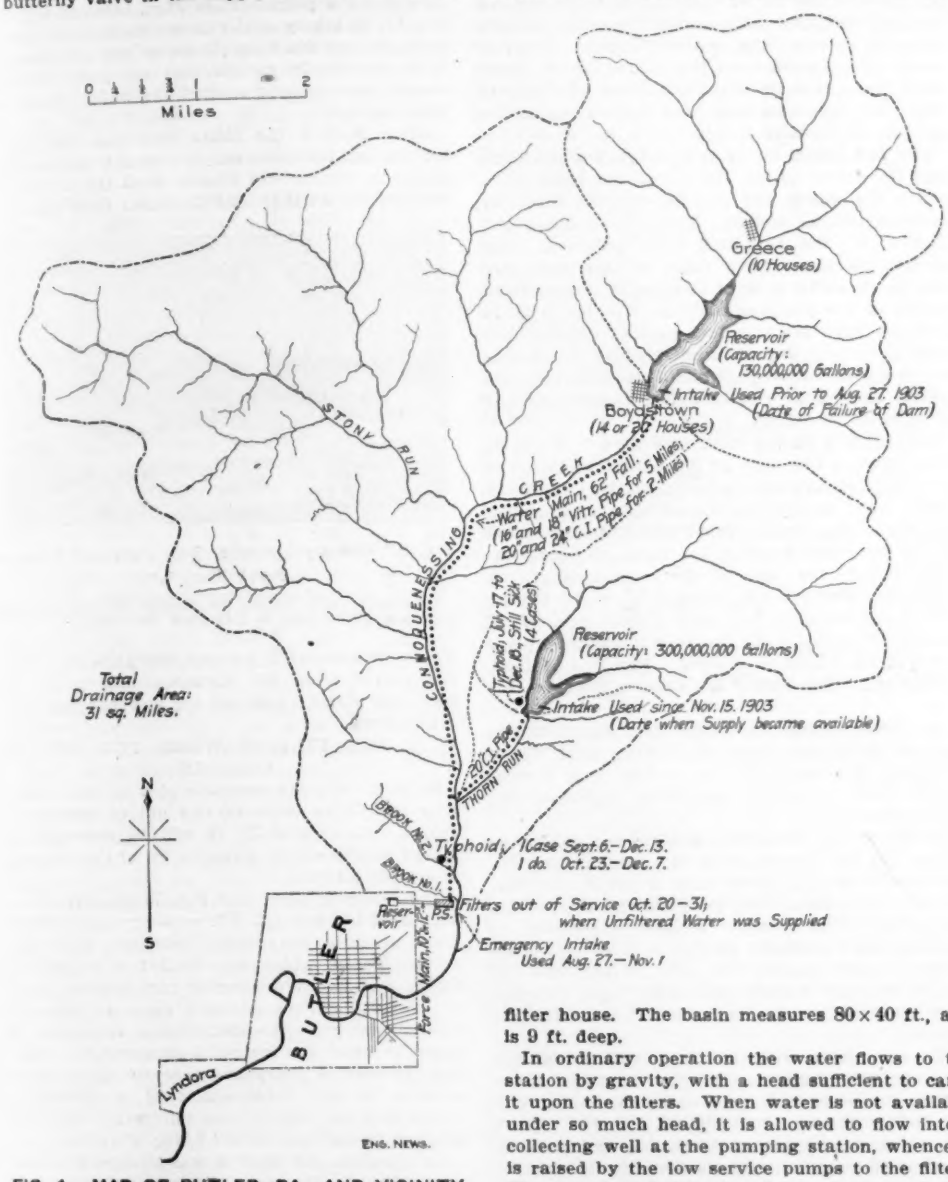


FIG. 1. MAP OF BUTLER, PA., AND VICINITY, SHOWING SOURCES OF WATER SUPPLY.

Fig. 3. Miner's Cabin in Which Two Cases of Typhoid Fever Existed Before the Butler Typhoid Epidemic.

(The cabin is about 75 ft. from Brook No. 2. The privy is shown at the left of the cabin.)

THE SANITARY CONDITION OF THE SOURCES OF WATER SUPPLY.

It will be observed from what has already been said, that the water company has three sources of water supply. It is desirable that the sanitary condition of these several sources be briefly considered.

(1) The Supply from the Impounding Reservoir Formed by the Boydstown Dam.—It appears that this has been and must continue to be the chief reliance of the borough. Some of the brooks which contribute to this supply flow near farmhouses, and one, at least, runs through a village of perhaps a dozen dwellings. Some sources of pollution exist on the stream above the Boydstown dam. At the little village of Greece City several barnyards and privies are situated near the banks of the water course. The drainage of the village of Boydstown does not enter the Connoquenessing supply above the dam.

There are no reliable statistics concerning the occurrence of typhoid fever in the drainage area tributary to the Boydstown reservoir. Physicians in that part of the country are not in the habit of reporting their typhoid cases, and it is only through the recollections of the inhabitants that facts can be gathered concerning the number of people who have suffered from this disease.

When it is considered that many cases of typhoid fever are almost certain to escape correct diagnosis because of the frequently mild and aberrant forms which it exhibits, it is apparent that typhoid might have existed to an extent dangerous to the water supply without its prevalence or presence being noticed. It is conceded by the residents on the upper Connoquenessing that typhoid fever occasionally occurs there, although no serious outbreak for many years has been recalled.

(2) The New Source of Water Supply Just Developed on Thorn Run.—The Thorn Run drainage area is smaller than that supplying the Boydstown reservoir, and is without villages. In other respects, the sanitary condition of the district is similar. The chief possibilities of pollution lie in scattered farmhouses.

A remarkable run of typhoid fever in a family situated on the drainage area (see Fig. 1) of Thorn Run should be referred to. The family is that of a farmer living on the precipitous bank of the Thorn Run reservoir above the dam. The first case occurred here on July 17. From that date to the present, typhoid fever has not been absent from this house. Four cases have occurred. The family has no knowledge of the correct principles of disinfection, and it seems unreasonable to suppose that they took unusual precautions to protect the purity of the neighboring water. In all probability, the wastes from the sick were thrown out upon the ground, as is usual in the country, in which event it is possible that some infectious material found its way into the empty reservoir below the house.

(3) The Water of the Connoquenessing Creek at the Pumping and Filter Station.—This was the source of supply which was drawn upon by the water company just prior to the epidemic. The country concerned includes that already referred to in considering the sanitary condition of the Boydstown and Thorn Run supplies, and, in addition, takes in a considerable extent of territory nearer the borough.

In that part of the drainage area of the Connoquenessing which lies between Boydstown and Butler, there has been a good deal of typhoid fever within a few years. Seven cases can be recalled by residents of the vicinity as having occured a mile or so south of Boydstown three years ago. Nearer Butler, cases of typhoid fever have been more frequent and recent. Within a half mile of the pumping station of the Butler Water Company there has been typhoid fever all this fall. Two cases occurred in the same household; the patients were the daughters of a coal miner who lives in a humble cottage (see view, Fig. 3) near the bank of the second brook (see Fig. 2) which enters the Connoquenessing above the water-works station. The first case in this family occurred on Sept. 6 and ran 14 weeks, to Dec. 13; the second case occurred on Oct. 23 and ran 45 days, to Dec. 7. Both cases were

Fig. 4. House Adjacent to Miner's Cabin.

(View taken from the bed of Brook No. 1. A privy is shown in the middle distance. A drain, not shown in the view, ran from the house to the brook.)

severe, the first especially so. The children were nursed by their mother and by neighbors who occasionally came to render aid.

The miner's dwelling lies within 75 ft. of the water in the brook and at an elevation of somewhat more than 10 ft. above the level of the stream. As to the methods of disinfection employed to destroy the germs of fever from these patients, no reliable information could be gained.

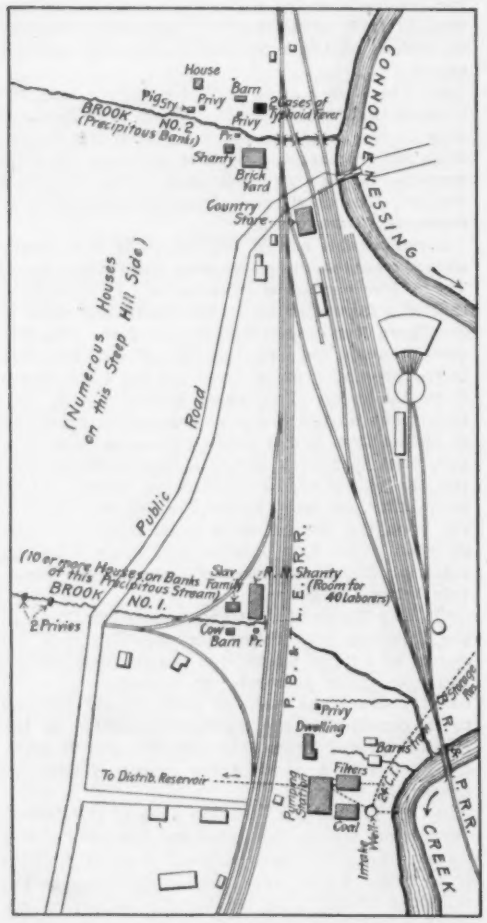


Fig. 2. Map of Vicinity of Butler Pumping and Filter Station, Showing Some of the Sources of Pollution of the Water Used Without Filtration, Oct. 20 to 31, Inclusive.

The mother was evidently prepared to answer questions on this point and insisted that the most scrupulous care had always been exercised to prevent any typhoidal material from entering the brook. It was thought worth while to inquire with some thoroughness into the precautions taken at this house since the unhygienic conditions under which the family lives made it seem improbable that any care whatever had been used in the disposition of the wastes. The physician who had attended the patients was questioned as to the methods of disinfection which he had directed. He had ordered, he said, that a certain brand of a patent disinfectant be used. The druggist who supplied the family with medicines during the long illness of the children was seen and asked if he had sold the family this disinfectant. He failed to remember that he had ever furnished the people with a disinfectant of any kind.

Taking these facts into account, considering the nearness of the brook, the slope of the land, the long period of the sickness, the usual habits of country people with respect to the disposal of excreta from the sick, and the viability of the typhoid germ, as shown by the history of other epidemics, it seems reasonable to believe that some of the wastes from these sick children may have found their way into the brook. It is not improbable that this brook was continually infected for many weeks (see Fig. 4 for an example of further probable pollution). The water of the brook undoubtedly entered the public water supply from Oct. 20 to Oct. 31, and was consumed by the people of Butler without previous filtration. This may have caused the epidemic.

But a reasonably satisfactory explanation of the cause of the Butler epidemic does not require a belief that typhoidal matter from the miner's children entered the water supply. Another source of pollution than the second brook above the pumping station offers a fairly good explanation. The epidemic may have come from an infection of the first brook.

The first brook above the pumping station enters the creek within 150 ft. of the point from which the water was pumped without filtration between Oct. 20 and 31. There is no doubt but that it is, and has long been, polluted. The surface washings from many houses flow into this brook within a short distance of a quarter of a mile of the pumping station. The brook is, in fact, an open sewer whose present channel has been purposely dug to accommodate the drainage of some bottom lands and a small ravine, into which, and about whose mouth, cluster perhaps a score of dwellings.

Immediately on the ditch (see Figs. 1, 2 and 5) and within a few rods of the pumping station is a railroad shanty with accommodations for forty men. Next to this is a second shanty, of nearly the same size. On the other side of the ditch are a cow barn and a privy, the latter obviously intended for the use of the occupants of the shanties. The privy is within 3 ft. of the stream and at an elevation of 4 or 5 ft. above it. That the brook at this point has been a dumping place for human wastes is obvious. Remains of food, ashes and other refuse are observable there to-day.

A few hundred feet above the shanties, two privies sit directly over the brook. (See Fig. 6 for one of these.) Within a few feet, several barns, pigsties, stables, and other outhouses line the stream.

It is needless to further analyze the conditions about the first brook above the pumping station. Inasmuch as it is practically a sewer, its contents must be considered to contain all the terrible potentialities of sewage. A case of walking, or unrecognized typhoid, or the visit of a convalescent whose bladder was infected with the typhoid bacillus, might reasonably have infected the brook sufficiently to have produced the epidemic.

To summarize what has been said concerning the sanitary condition of the drainage areas which furnished unfiltered water to the borough of Butler between October 20 and 31: There were many sources of pollution, and possibly several of infection; typhoid fever in the country was by no means unknown and probably occurred to a greater extent than can now be determined. At least six cases of typhoid fever were present between July 17 and the date of the epidemic. Four cases have existed on the main tributary since July; two cases were present on a brook within a mile of the intake of the water supply. Another brook whose surroundings show that it must have contained excrement and possibly typhoid germs enters the Connoquenessing within 100 ft. of the intake of the water supply at the pumping and filter station.

OPERATION OF THE WATER-WORKS SYSTEM JUST BEFORE THE EPIDEMIC.

The Boydstown dam, which had been constructed before the present company obtained control of the water-works, failed on July 27, 1897. Owing to severe rains and want of proper construction, the eastern half of this earth embankment was washed out. The half which was destroyed was immediately rebuilt by the company and remains in satisfactory condition to-day. On Aug. 27, 1903, the other half gave way. As had been done before, the company set to work to repair the damage. Until the old dam at Boydstown could be repaired or the new source of supply from Thorn Run would become available, the company decided to take its water from the Connoquenessing Creek at the pumping station. Therefore, from Aug. 27 until about Nov. 1, the water supply for Butler was derived from the Connoquenessing Creek, close to the borough limits. For the greater part of this period the water was filtered through the rapid, or mechanical, filters. Toward the close of October the filters were shut down to permit a connection to be made with a new pump. They remained out of service for a period of ten days, between Oct. 20 and 31, as nearly as the dates can be determined. During these ten days the water was not filtered. It is practically certain that the germs which caused the epidemic entered the water supply in this interval.

After Nov. 1 the filters were put back into service and the water supply from the creek at the pumping station was filtered until the middle of November. At that time the water from the new

Fig. 5. Railway Shanties, Cow Barn and Privy on Brook No. 1.

(The brook runs between the shanties and the privy and cow barn. The privy is 3 ft. from the brook.)

Thorn Run reservoir became available. After this the supply from the Connoquenessing at the pumping station was cut off and has not been used since.

WHY THE FILTERS WERE PUT OUT OF SERVICE.

In order to get a complete idea of the reasons why the filters were thrown out of service between Oct. 20 and 31, it will be necessary to glance briefly at the arrangement of the pumping and filter station.

The pumping plant (see Fig. 7) consists of two boilers of 100 and 125 HP. capacity, respectively. Until recently the pumps consisted of a low-service pump, which was needed to supply the filters, and two Worthington high-service pumps of 2,500,000 gallons capacity each, to force the filtered water to the distributing reservoir. In order to meet the increased demands for water, the low-service pump had recently been supplemented by the construction of a centrifugal pump, and the high-service pumps had been duplicated by an R. D. Wood 5,000,000-gallon pump.

To complete the work it was necessary to connect (Fig. 7) the new high-service pump with the filtered water basin and to join the new centrifugal with the old low-service piping. This necessitated the emptying of the filtered water basin and the shutting down of the filters which supplied it until the changes could be completed. It is not clear why this work should not have been postponed until the water from the new Thorn

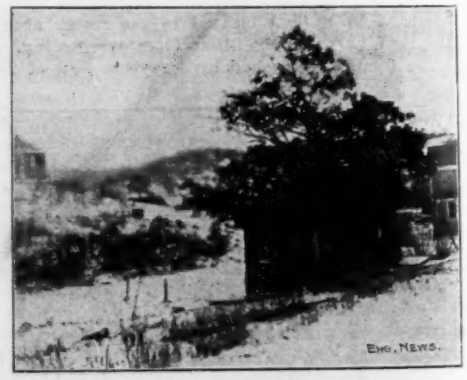


Fig. 6. Board Shanty with Privy in the Rear, Directly Over Brook No. 1.

(A further illustration of the insanitary condition of the drainage area in close proximity to the pumping station.)

Run reservoir was available. The need of making the connection at a time when so much depended on the efficient action of the filters is not evident. Apparently the question of the danger from the polluted water of the Connoquenessing at the station was not considered.

As many men as could be handled were put upon the work and the alterations were pushed as rapidly as possible. When the new centrifugal and the high-service piping had been connected, the opening in the wall of the clear water basin was closed and the filters were put back into service.

THE OUTBREAK OF THE EPIDEMIC.

The first intimation that an epidemic had settled upon Butler came from the large number of calls for doctors during the first week in November. Within ten days from the time the filters were put out of service and the polluted water of the Connoquenessing supplied from the intake at the pumping station, the physicians were doing more business than they had ever seen before. In the next fortnight, the large amount of sickness in the borough had become the chief subject of discussion on the streets. By the fourth week in November it was known that many hunderds of homes were visited by typhoid.

On Nov. 29, a mass meeting of citizens was called, and there assembled in the courthouse as many people as could gain entrance. The gravity of the situation was then appreciated, and it was evident that heroic measures must be taken to relieve the sick and protect the rest of the community. The board of health did not rise to the requirements of the situation. In fact, it failed to respond to the open call of the burgess, and beyond holding a few lethargic meetings accomplished nothing. The forty physicians at Butler did not report their cases. There seemed no need. They had never been required to do so. To illustrate the unreliability of the vital statistics, it is only necessary to state that the total number of cases of which the local board of health had record at this time was 42; the actual number of cases, as estimated from a canvass of the city, made later by the citizens, was 1,000.

The disease broke out simultaneously in nearly every part of the city, one section alone, which receives its water from artesian wells, enjoying comparative immunity. On Dec. 11 the reports from canvassers indicated the following numbers of cases in the different wards:

	Cases.		Cases.		Cases.
Ward 1...	117	Ward 3...	190	Ward 5...	290
Ward 2...	276	Ward 4...	265		
Total					1,138

During the next five days the reports from the respective wards were as follows:

	Wards					
Date.	1st.	2d.	3d.	4th.	5th.	Total.
Dec. 13—Cases	1	0	0	1	1	3
Deaths	0	0	0	1	0	1
Dec. 14—Cases	1	0	0	4	5	10
Deaths	0	0	0	0	0	0
Dec. 15—Cases	1	2	3	0	0	6
Deaths	1	0	0	0	1	2
Dec. 16—Cases	..	2	2	1	0	5
Deaths	..	0	1	1	0	2
Dec. 17—Cases	0	2	0	2	0	4
Deaths	0	0	0	1	1	2
Total—Cases	3	6	5	8	6	28
Deaths	1	0	1	3	2	7

The official figures of the state board of health, based on partially independent data, are, to Dec. 17, 1,270 cases and 56 deaths.

THE RELIEF WORK.

At the mass meeting of citizens held in the courthouse Nov. 29, a relief committee was elected and a systematic campaign was begun. The membership of this committee comprised many of the leading business and professional men of the borough. They at once began the work for which they were selected. Headquarters were established and a representative was appointed for each of the five wards of the borough. Each ward chairman, as he was called, then appointed four assistants, who set out to make a house-to-house canvass to determine the location of patients and the needs of each family. In some cases it was found that every member of a household had been stricken with typhoid fever; in other cases all but the wage earner were ill, and in some instances he was compelled to leave his employment to nurse his family. Disinfectants and their use, and the proper means of nursing and caring for the sick, were unknown to most of the people. The number of sick was so large that only the worst cases could receive frequent medical attendance. Instances were found in which no physician had visited the sick for four or five days. The citizens' relief committee procured the services of trained nurses, calling upon the resources of Pittsburg, Philadelphia, Rochester and other cities to supply their needs. To accommodate the sick in the best manner practicable, emergency hospitals were opened, and for this purpose hotels, private dwelling houses and a building intended for a liquor saloon were pressed into service.

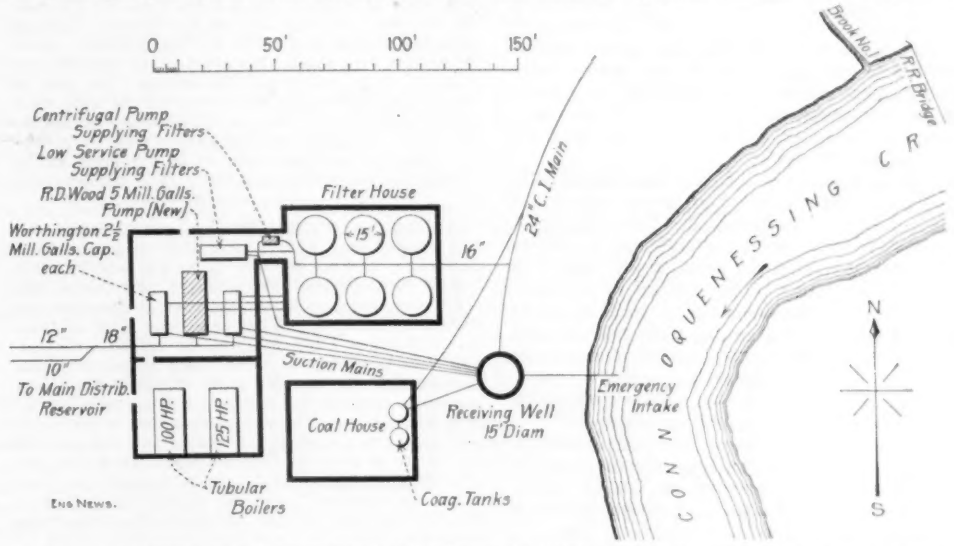


FIG. 7. SKETCH PLAN OF PUMP AND FILTER HOUSES, SHOWING CONNECTIONS WITH SUPPLY MAINS, THE POLLUTED CREEK, THE MECHANICAL FILTERS AND THE CLEAR WATER BASIN BENEATH THE FILTERS.

Regular meetings of the relief committee and of several subsidiary committees now take place in Butler every night. On these occasions the ward chairmen report the number of new cases and the number of deaths from typhoid fever and other diseases which have occurred in the last 24 hours within their districts. The essential developments of the epidemic situation are then reviewed and such new measures of relief as seem necessary are decided upon. A large part of the active work of the relief committee is in the hands of Mr. R. H. Brodhead, a railroad contractor, whose experience in organizing and directing labor stands the committee in valuable stead. Books are kept, to show the needs of every case requiring relief, as well as to indicate the succor which has been afforded.

To meet some of the most pressing needs of the situation, some aid has been afforded by voluntary workers from other cities. Chief among these was the corps of physicians and nurses from Philadelphia and a red cross society from Philadelphia. The action of these, and of many noble men and women of Butler, in laying aside their private occupations to help the sick are beyond praise.

In order to meet the expenses of the relief work undertaken by the committee of citizens, financial aid is, and will be, required. Voluntary contributions to the extent of about $25,000 were received by Treasurer T. J. Schuffiin up to the middle of December. It was then estimated by Miss Clara Barton, president of the Red Cross Association of America, and by others familiar with extensive relief work, that at least $75,000 more would be required. The finances of the borough make it impossible to rely upon local aid beyond that which has already been given. On Dec. 16 an appeal for aid from the citizens' committee to the outside world was published.

Such money as is sent to Butler for use in the epidemic will be employed to relieve the sufferings of the sick.

OPERATIONS OF THE STATE BOARD OF HEALTH.

At the solicitation of the school board, urged by the energetic efforts of some of the citizens, the state board of health came upon the scene on Nov. 29. The state board, through Dr. Wilmer R. Batt, State Quarantine Officer, made an investigation and, satisfied of the extent of the epidemic and of the probability of its continuance, established headquarters and assumed the responsibility of the sanitary measures which, in its view, the situation called for. Disinfectants, mostly of the patented variety, were ordered and distributed by the State board in quantity. Instructions were issued in the form of printed notices to teach the people how to make proper use of the disinfectants. A house-to-house canvass was made to obtain accurate data of the spread of the epidemic. The sources of water supply were inspected, and to protect the waters of the Thorn Run reservoir from infection by the typhoid family on its shore, an intercepting ditch and embankment were constructed below the house. The farmers supplying milk to the people of Butler were visited, and steps taken to prevent the milk from becoming infected. As a means of affording some measure of protection to the water supplies of several communities located on the Connoquenessing below Butler, an attempt was made to disinfect some of the Butler sewage. For this purpose several small sewer lines were broken, and trenches were dug, measuring about 10 × 12 ft. by 6 to 10 ft. deep. Several of these trenches or basins were arranged in series, and the sewage conducted from one to another before being allowed to continue its course to the creek. The sewage in each basin was dosed with unslaked lime and copperas. The trenches were then covered with loose boards as a precaution against the frost.

Complete unanimity exists between the officers of the state board of health and the relief committee of citizens.

COMPARISONS AND PRESENT STATUS.

It is still too early to take the full measure of the epidemic, but the most reliable statistics which can be obtained, place Butler above all other epidemics of typhoid fever of recent times in the number of cases which have occurred. Following are the data of the most extensive typhoid epidemics which have taken place in the last twenty-five years.

Place.	Date.	Population.	Number Cases.	Number Deaths	Cause.
Caterham, Eng....	1879	5,800	252	21	Water supply
Plymouth, Pa. ...	1885	8,000	1,104	114	
Ithaca, N. Y.....	1903	13,000	1,300	78	
Butler, Pa.	1903	18,000	1,270*	56*	

*To Dec. 17.

The number of deaths at Butler, as compared with the number of cases, appears small and will likely remain so. In the only other epidemic of typhoid with which Butler should be compared—Ithaca—the proportion of deaths to cases was far smaller than the text-books would lead one to expect. It is probable that the proportion of

deaths at Butler will increase, for a large number of the cases have not yet passed through their critical states, yet a very low death rate should be anticipated.

There will undoubtedly be more cases due to the epidemic than will be known. The disease has already been scattered wide from Butler, and local transmission will continue.

As to the length of time which the epidemic may last, nothing definite can be prophesied. Much depends upon the effectiveness of the prophylatic measures which the state board of health sees fit to employ and the spirit with which the public co-operates in this work. It is probable that the worst is over. Provided proper care is exercised in the operation of the water-works and sufficient vigilance is employed to prevent the further transmission of the disease from person to person in the borough, the epidemic should slowly die out.

At the present time it is not improbable that all of the possible sources of water supply are in danger of becoming infected. Numerous cases of typhoid fever from Butler are being nursed in the country supplying the borough with water. A failure of the filters, even though temporary, might cause another outbreak of typhoid. It is said that the filters were not built for bacterial efficiency, but to remove the clay and other earthy impurities. From now forward they will be called upon to perform the most delicate work for which a water purification plant is ever designed.

To attend to the interests of the water company there are at Butler at the present time, besides a regular force of employees, Mr. M. D. Hays, Resident Engineer, and Mr. J. E. Witherill, Bacteriologist.

DYNAMOS DRIVEN BY GAS ENGINES will be used in a new central lighting station at Berlin, Ontario. The engines will use city illuminating gas of 650 B. T. U. calorific value. Four vertical engines aggregating 460 HP. in capacity are to be installed at first, three of them being 13 × 14-in. 3-cylinder engines of 125 HP. each, and the fourth an 11 × 12-in., 3-cylinder engine of 85 HP. The Westinghouse Machine Co., of Pittsburg, Pa., is building these engines.

GASOLINE STREET LIGHTING may be adopted by the city of Muscatine, Iowa. There has been a controversy between the city and the Citizens Railway & Light Co. as to the charge for street lamps, and in July the company made a proposition to charge $100 per light per year for 50 arc lights of 2000 c. p., burning all night, and $1.25 per 1000 cu. ft. of gas for private consumers. The city lighting committee referred this to the council, without recommendation, and the council placed it on file, which amounted to a rejection. At the end of October the company removed its arc lights from the streets, which have since been lighted only by a few gasoline lamps erected by firms asking for contracts for gas and gasoline lighting. The mayor, Mr. Robert S. McNutt, informs us that the council has passed on its second reading an ordinance giving a contract to the Cleveland Vapor Light Co., of Cleveland, O. This ordinance fixes the price at $25 per year for each light, the lights to burn all night.

A REPORT AGAINST A MUNICIPAL ELECTRIC plant at Binghamton, N. Y., has been made to the common council of that city by a special committee. The committee presents statistics from a few other cities designed to show that the lighting service now rendered by a company is costing less than is being paid elsewhere under both private and public ownership. It urges that a municipal plant would mean a large increase in the labor cost of electric lighting, because city men work only eight hours a day, while the men now employed by the lighting company work ten hours a day. The committee also urges that other municipal needs, including trunk sewers, should take precedence of expenditures for a municipal lighting plant.

A TRIAL OF STEAM TURBINES FOR NAVAL vessels has been recommended by a board of naval officers appointed by the U. S. Navy Department to consider the question of turbine engines.

AN INCOMBUSTIBLE INSULATION FOR ELECTRIC wires has been invented and is being put on the market by the Teter-Heany Developing Co., of York, Pa. The insulation is stated to be strong and flexible, and to resist abrasion or similar mechanical injury. It is also weather proof and moisture proof in all ordinary situations, and where wire is to be actually placed under water it can be waterproofed without detracting from its fireproof qualities. Tests of the insulation by heating to a red heat many times in succession have shown no deterioration and the current has been raised to such a point that the copper wire itself fused. The composition of the insulation material is not made public, but it is said to consist of a fibrous web applied to the wire in a flocculent form and with its interstices filled with a certain chemical. The insulation is said to be no more costly than a double nap of cotton and to be of less thickness.

If these claims can be substantiated it would be difficult to overestimate the importance of the invention in the construction of all classes of electrical machinery.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the St. Louis & San Francisco Ry., near Godfrey, Kan., on Dec. 21. A fast through passenger train was derailed at a switch and was wrecked. About ten persons were killed. The cause of the wreck is supposed to be the following: The passenger had right of way, but a freight train broke down on the main track and the switch was thrown for the passenger to take the side track. A flagman was sent back to warn the passenger train, but the latter came on at full speed and in consequence was thrown from the track at the switch.

EXPLOSIONS OF DYNAMITE are again becoming common items of news, as invariably is the case when freezing weather sets in. On Dec. 17, at Du Bois, Pa., four Italians "in Contractor Lauer's shanty, near Cramer Station," were blown up by the explosion of dynamite that they were "warming." A day or so later a box of dynamite exploded in a tool house in the Botanical Gardens, New York City. The explosion shook houses for blocks around and broke some 200 panes of glass. One of the laborers in the park was struck by a flying beam and injured so severely that he will probably die. What caused the accident is a mystery. A laborer had just removed eight sticks of dynamite from the box a few minutes before the explosion occurred. "It is believed that frost caused the explosion," says one report; but it is more likely that a match or cigar stump was the cause of the accident.

A WOODEN BRIDGE FELL DURING ERECTION at Port Royal, Montgomery Co., Tenn., on Dec. 7. According to a report furnished us by Mr. S. R. Alexander, City Engineer, of Clarksville, Tenn., the bridge was of 192 ft. span with 16-ft. roadway, with trusses of the bowstring type. Before the erection was completed the falsework began to sink in the mud, and the contractors began taking out the falsework. The collapse resulted. The bridge was being built for the county.

AN EARTH DAM AT HALEDON, N. J., gave way on Dec. 15, damaging property and flooding a number of mills so that they had to be shut down. The dam formed what was known as Hopper's Pond.

THE CONCRETE FLOOR ACCIDENT at Pittsburg, Pa., noted in our last issue, was due to carelessness of workmen in using faulty shores for the concreting forms. The floor is in 12-ft. 9-in. by 16-ft. 3-in. panels, and is the regular long-span flat ceiling construction of the Expanded Metal Companies. The building in question, the Bellefield Apartments, is 9 stories high. Most of the floorwork was in, when the roof concreting was begun in order to get the building under cover. In one panel the foreman employed spliced shores, and when the panel was nearly all in the shores broke. The wet concrete fell two stories before striking a floor, which latter was freshly placed. As a result it broke through and the mass went through the remaining floors to the basement, a total of eight tiers. No damage was done outside of this one panel, and no steelwork or other work was affected. We are indebted for our information to Mr. Carlton Strong, 170 Broadway, New York, who is architect for the building.

SANDJACKS WERE USED TO LOWER A BRIDGE 10½ ft., after it had been shifted 35 ft. up stream, Dec. 20. The bridge is a 220-ft. span, double-deck draw bridge over the Passaic River on the line of the Delaware, Lackawanna & Western R. R. This novel and interesting engineering feat will be described in full in our next issue.

SURVEYS FOR THE N. Y. BARGE CANAL have begun. Six parties, comprising 50 men, are now in the field in the Fort Bull-Oneida, Savannah, Rochester, Medina and Tonawanda sections. Actual construction will probably not begin before May 1, and may not begin then unless bidding prices are within the State Engineer's estimate of cost. These six sections are in fact test sections to determine whether the whole canal work can be done within the $101,000,000 that the citizens of the state have voted for the cost of construction and interest on the canal bonds.

A WATER POLLUTION SUIT has been brought jointly by the Jersey City Water Supply Co., the East Jersey Water Co. and the municipal corporation of Jersey City against the Cooper-Lord Estate, which last has been maintaining an out-house a mile above the new Boonton Dam of the Jersey City water-works. A temporary injunction was at once granted by the Court of Chancery, and Dec. 14 was set as a date for arguments on a permanent injunction.

DAMAGES FOR BACKING UP SEWAGE in a house connection and overflow into a sewer have been denied to a property owner in Woodbridge, N. J., by the Supreme Court of New Jersey. It was shown that a 12-in. sewer was built in front of the property in question, and that the property was assessed therefor. It was alleged that a proper connection was made with the sewer by the property owner, but that owing to a deficient grade or lack of capacity in the street sewer the cellar of the plaintiff was flooded with sewage. The court held that since the sewer connection was entirely of the plaintiff's construction the complaint really was that the town had constructed a street sewer with such a capacity and grade that the plaintiffs could not practicably connect their cellar therewith. The decision then went on:

This complaint is without legal basis. The general doctrine on this subject is that, in devising a plan for the construction of public sewers the public authorities discharge a quasi judicial duty, involving the exercise of judgment and discretion with regard to general convenience, and that their wisdom in the performance of that duty is not subject to review in a private suit brought to recover damages because of this error. They owe to no individual the duty of devising such a plan as will afford to him sufficient drainage.

The court next pointed out that the case was quite different from one where flooding of premises had been caused by the failure of a town to keep a sewer in repair, or free from obstruction, or where a trunk sewer had been overburdened by connecting to it lateral after lateral beyond its capacity. In the present case the damage had been caused by the action of the plaintiff's themsives. The assessment paid by the plaintiffs must be assumed to have been equivalent only to the benefits conferred by the sewer, which appears to be "fit to afford drainage for all parts of the house above the cellar." The argument and decision was on a demurrer entered by the town in a suit for damages. Judgment was entered for the town on the demurrer.

ASHES AND OTHER RUBBISH need not be removed from department stores by the New York Street Cleaning Department, if in the judgment of the department its funds will not warrant the expense; such is the decision of the Appellate Division of the Supreme Court of the State of New York, in a suit brought by members of the Retail Dry Goods Asosciation. Dr. John McGaw Woodbury, Commissioner of Street Cleaning, claimed that the output of steam ashes and other wastes from the department stores was so great that he could not remove it without neglecting work more essential to the public interests. All the justices concurred in the opinion, in effect, but Presiding Justice Van Brunt write the following brief and far-reaching individual opinion:

I concur in the result. I do not think the Commissioner is bound to remove trade waste, whether in the form of ashes, garbage, or any other form of refuse matter.

ACTINIUM, A NEW ELEMENT, has been isolated by M. Debferne, and a small quantity of it has recently been received by Dr. Geo. F Kunz, M. Am. Inst. M. E., the mineral and diamond expert at Tiffany's, New York city. The new element is akin to radium, and is obtained from pitch blende. While its rays have not the penetrative power of radium, they are remarkably profuse for a time. In the darkness it is only slightly luminous, but it causes a peculiar foggy phosphorescence in willemite. On diamonds it acts to produce a phosphorescence that extends into the space between the diamond and the actinium. Dr. Kunz recently exhibited the action of actinium in a lecture before the Princeton Chemical Society. Prof. Alexander H. Phillips, of Princeton University, has been experimenting with minerals in order to ascertain whether radium is to be found on this continent. He has at last discovered it to exist, beyond all question, in the carnolite from Utah.

THE CATALPA SPECIOSA as a quick growing tree for use where early returns on forestry work are wanted will be the subject of an exhibit at the St. Louis Exposition. The exhibit will be under the auspices of the International Society of Arboriculture, the secretary and treasurer of which is Mr. John P. Brown, of Connorsville, Ind. It is stated that the exhibit will include forestry methods as well as products and their uses, all as related to the catalpa. About 200,000 catalpas were planted by the Illinois Central Railroad Co. a few years ago at a point near Du Quoin, Ill.

THE COAL RESOURCES OF THE YUKON, ALASKA, is the subject of Bulletin No. 218 of the U. S. Geological Survey. The coal thus far discovered is either a lignite, or a low-grade bituminous coal; and up to the present not more than 9,000 tons have been mined, all told. Because of the limited extent of the coal beds, the low grade of the coal, and the cost of mining, the coal of the Yukon valley will probably never be exported; but with proper development the mines will furnish sufficient coal for local consumption.